POWER

Volume 59 New York, February 12, 1924 *No. 7*

Recognition Follows, Not Leads, Service

I TALKED the other day with one of those disciples of discontent, the fellow with a grouch, to whom the world has not paid what he thinks it owes him.

What he could not do if he had some men's chances would not be worth while; what he did not know about engineering was not in any book; but he was running a small job and running it but indifferently.

"Sure" there were a lot of things that could be done to improve the plant and to get better results from it as it was, but so long as the firm treated and paid him like a day laborer it was not up to him to do expert engineering for them. If they wanted to pay him for his "professional" knowledge and ideas, he was there with the goods, but for day's wages—nothing doing.

And so there was nothing done, and he kept on working by the day at a wage commensurate with what he delivered.

Employers do not hire men upon faith or upon their representations of what they can do. They want to be shown. Fellows who have more front than filling, fool them sometimes, but they do not last. The man who gets the big job with large responsibilities and remuneration, grows into it by doing things and demonstrating his capability.

If he does not go ahead in his original position, he makes a record that enables him to sell his services elsewhere, and the making of which fits him for the bigger and better situation and prepares him for the reward of him who is faithful over small things.

True, there are employers who will accept all that a man will do for them and load him with all that he will take on without revising their conception of him and of their obligation to him in accordance with his growing importance. This is especially true when a man starts small and is not a good salesman of his own services. It is human nature to pay no more than one has to and to let one who is apparently contented alone.

An engineer in the making will always do more than he is paid for. If, after he has made a record, and after the use of legitimate means to impress his employer with what he is doing, he feels that he has reached the limit of achievement and appreciation where he is, it is time to quit.

But he will seldom or never cash in on that vision of the great things that he might do if it were only made worth his while.

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is used in the same way as a basement is ordinarily used. The firing floor or main operating floor, which is 17 ft. above the ground floor, is in reality the second floor. This floor is common to the boiler room, turbine room and switchhouse.

The floor of the switchboard room is 15 ft. above this main operating floor. Directly in front of the main switchboard and projecting out approximately three feet into the turbine room, a bay window has been provided, which allows the switchboard operators a clear view of all generating equipment, including most of the auxiliaries. The chief engineer's office and the general plant offices are also on the switchboard floor. In the northeast corner of the switchboard room a storage-battery room has been provided.

On the main operating floor of the switchhouse and south of the bus-structure room is the main entrance hall, which leads to the turbine room and plant offices on the switchboard floor. The reactors are in a room on the ground floor directly under the bus-structure room. An oil room and machine shop is also located on the ground floor of the switchhouse.

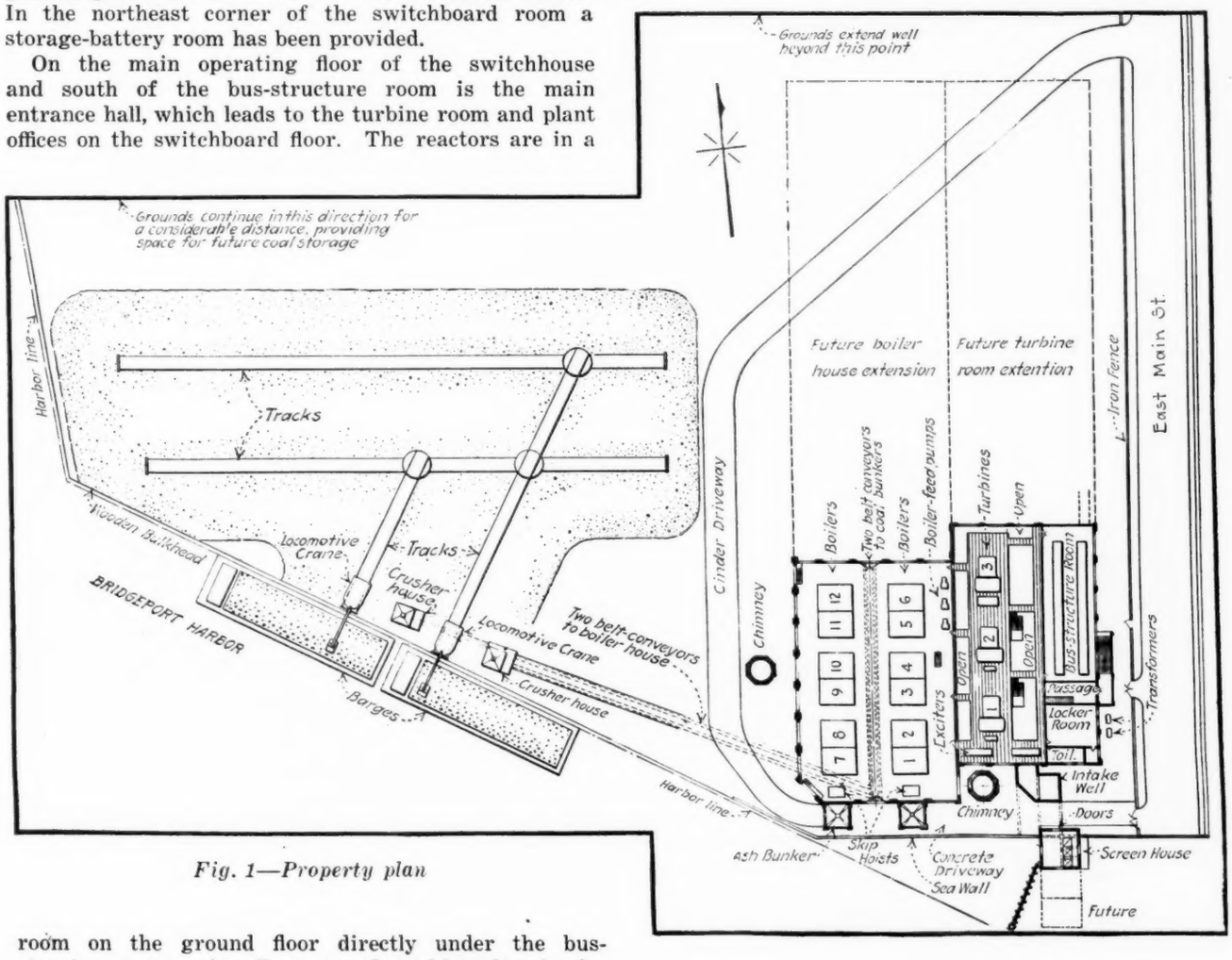


Fig. 1—Property plan

Two radial brick stacks, each 175 ft. high and having an inside diameter of 12 ft. 6 in. at the top, accommodate the present installation. The color of the brick selected for the stacks matches the color of the brick of which the building is constructed.

The design of this station has been influenced by the owner's inclination to seek reliability and continuity of service rather than extreme efficiencies and economies. The latter characteristics have, however, been given every consideration, but when it became necessary to make a choice, dependability was of course given the right-of-way. Continuity of operation being the key requirement, it was decided that all small equipment should be duplicated to prevent shutdowns caused by failure of auxiliaries. The major equipment may also be easily sectionalized, thereby allowing the station to be operated on a unit basis plan, should any trouble be encountered with part of the generating apparatus.

The heat balance for the station is obtained through the duplex steam and electrically driven exciters. These machines have been designed to float automatically on the line. The drives of various auxiliaries have been carefully selected to operate in conjunction with these exciters, and in this way an approximately correct amount of heating medium is available at all loads. It is planned, however, to duplicate certain units later with steam or electric drives, as the need may be disclosed, to further perfect the heat balance.

Accessibility of all equipment, aided by maximum admission of daylight and proper ventilation, has been given special study. Electrically operated steel sash have been used throughout the building. All apparatus has been located to afford the minimum of attendance and yet be easily get-at-able when necessary.

All piping has been designed with simplicity and continuity of operation as the governing factors. The main header, which is 12 in. in size, has been valved to accomplish complete segregation and isolation of units should conditions warrant. Motor-operated valves have been provided in the main header as well as in the turbine leads for this purpose. These valves have been furnished with one "closing only" station for each valve,

together with necessary relay panels and control stations for opening and closing any valve from two conveniently located points. Non-return valves have been placed at each boiler nozzle.

Coal-Handling Equipment

The coal-storage yard and the unloading and reclaiming equipment, as shown in Fig. 1, is a temporary expedient for the present requirements only. The capacity of the yard storage is now approximately 15,000 tons, with a future storage capacity exceeding 40,000 tons. Locomotive cranes, on tracks elevated approximately 4 ft. above grade, unload the coal from barges to the storage piles or directly into either of the two crusher hoppers. Run-of-mine-coal is discharged directly into the receiving hoppers, which form part of the roof of each crusher house, and from here it is delivered to shaking feeders which discharge their coal to the two roll crushers.

From the crusher houses two inclined-belt conveyors 20 in. wide and running at a maximum speed of 200 ft. per min. and each capable of conveying 60 tons of coal per hour, carry the coal to the overhead concrete coal bunker, which extends the full length of the boiler house and is directly over the firing aisle. Two horizontal belt conveyors of the same width, equipped with trippers and running at the same speed, deliver the coal from the inclined belt to any desired section of the bunker.

The coal-handling equipment feeding the plant bunker is permanently installed. Its characteristics are simplicity, with automatic yet flexible control, ease of maintenance and extremely low labor costs. The motors driving the crushers, inclined conveyors and tripper belts are three-phase 60-cycle 440-volt totally inclosed slip-ring type units, automatically controlled from push-button stations.

From the overhead bunker coal is distributed to the six boilers on each side of the firing aisle by one 10-ton electrically operated weigh larry. This is composed of two 5-ton hoppers arranged to feed into the stoker hoppers on each side of the firing aisle. The larry is provided with an interlock which operates in conjunction with the bunker coal gates. This interlock eliminates the possibility of opening any coal gate until the larry is placed directly below the gate, or of moving the larry until the gate has been properly closed. The larry operator, who rides on an elevated platform, has a perfect view into all of the hoppers.

Simple Ash-Handling System

The ash-handling system is equally simple, composed of a few sturdy and self-contained units. The sturdiness and simplicity of this equipment has made possible extremely low labor costs.

Ash hoppers of a large capacity, constructed of steel plate and lined with hard-burned red brick, have been provided under each boiler. These hoppers have been equipped with steam-operated ash gates, which discharge directly into ash cars of 95 cu.ft. capacity. There is sufficient headroom to allow motor trucks to be driven under the ash hoppers and loaded with ashes should the storage-battery ash cars for any reason be out of operation.

The ash cars, which are equipped with solid rubber tires, are driven by electric storage batteries of the Edison type. These batteries are charged by means of a special motor-generator charging set having automatic charging control equipment. These cars deliver the ashes to two independent skip hoists, by which the ashes are elevated and discharged into the exterior ash bunkers, located on the dock line at the south end of the boiler room. Each skip hoist is directly on a line with the ash hoppers, thus permitting of the rapid disposal of ashes. This handling is all done entirely inside of the building as far as station operators are concerned. Hence, winter difficulties are avoided.

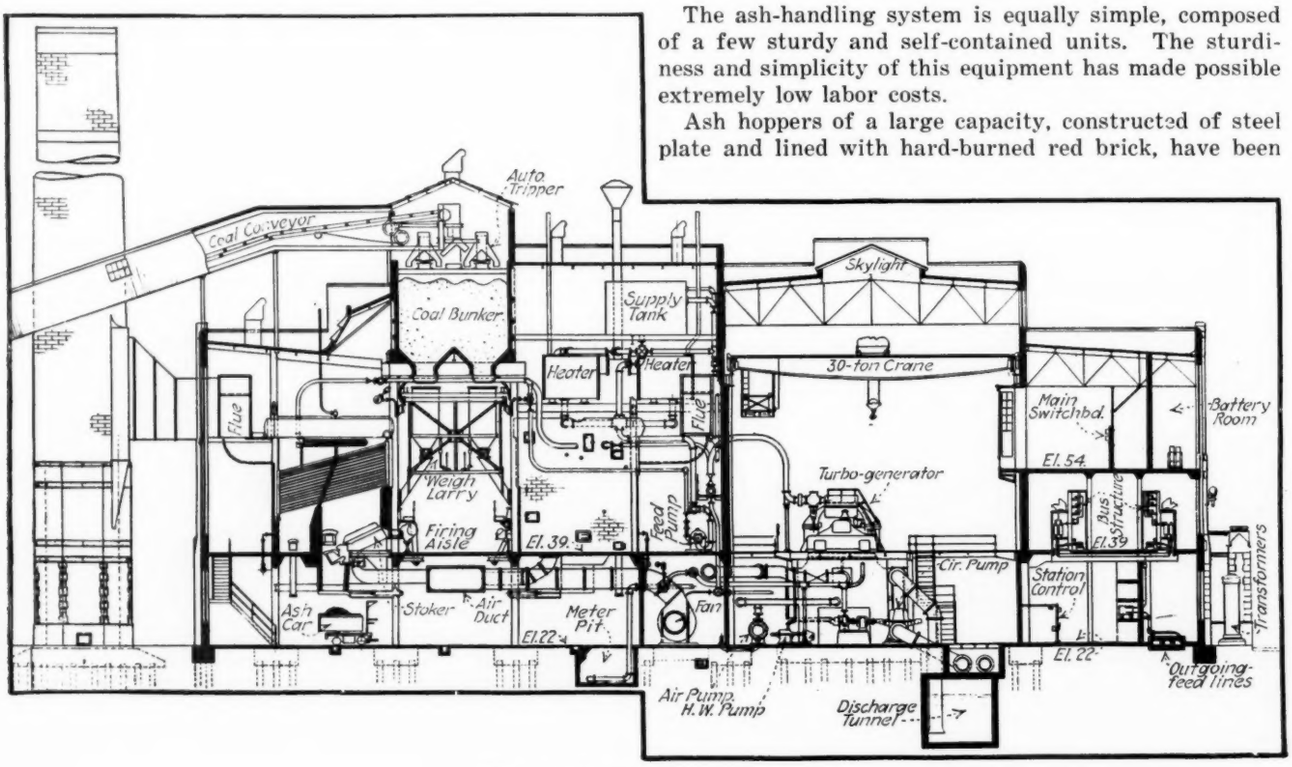


Fig. 2—Cross-section of plant

The two large exterior reinforced-concrete ash bunkers shown in Fig. 1, and also at the head of this article, hold about seven days' present plant capacity with boilers operating at 200 per cent of rating. As is evident from the photograph, the ash bunkers are designed for the maximum of utility without in any way detracting from the architectural dignity of the structure. These bunkers discharge their contents by gravity into motor trucks or later by means of a short conveyor directly into barges.

Boiler-Room and Its Equipment

The boiler room is 145 ft. long, 95 ft. wide and 86 ft. high. Twelve 7,546 sq.ft. sectional water-tube boilers set in batteries of two, totaling 15,092 sq.ft. each, are now installed. The boilers are of the three-drum type, sixteen tubes high. The tubes are 20 ft. long, 4 in. in diameter and expanded into forged-steel vertical headers. Superheaters are installed above the first and second passes of each boiler. These are proportioned to superheat the steam approximately 115 deg. F. when the boilers are operated at 200 per cent of their rated capacity. No economizers are used. The steam pressure is 225 lb. The boilers are to be operated at 200 per cent of rating and are stokered to operate up to 275 per cent of rating for two hours.

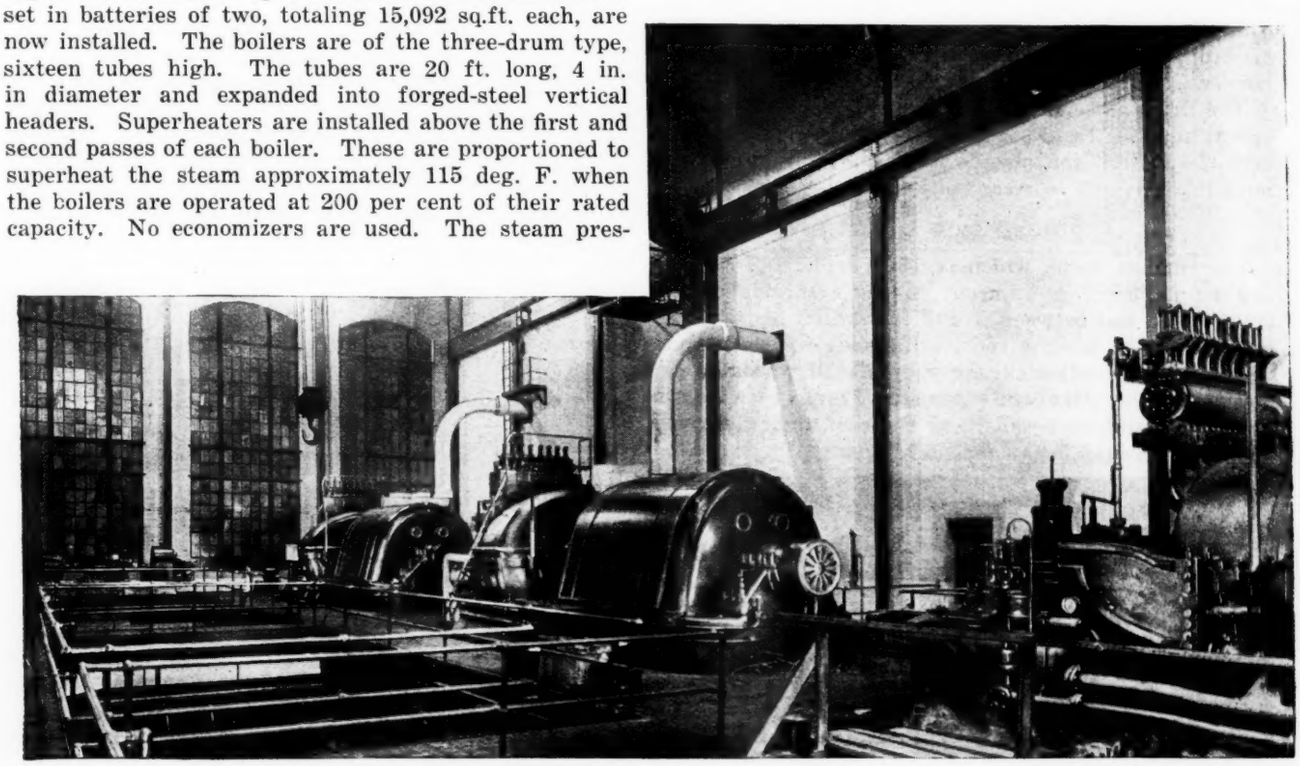


Fig. 3—General view of turbine room showing 10,000-kw. units

Each boiler is equipped with a 7-retort, heavy-duty, underfeed stoker, furnished with steam-operated ash dumps. The stokers are operated through common line-shafts located near the ceiling of the first floor, on each side of the firing aisle. Each shaft is driven by two vertical steam engines, one of which is a spare. A walkway extending the full width of a boiler battery and located in front of each stoker hopper has been installed to permit the operators to observe stoker-feed conditions.

The boiler settings are of the usual design for the type of boiler installed. Perforated blocks have been placed below the top of the approximate upper line of the fuel bed, in the front, side and bridge walls to prevent slagging and clinkering. These blocks allow the bypassing of air directly from the stoker wind-boxes and have suitable dampers provided to control the flow of air to all sides of the furnace.

The boiler baffles are of monolithic construction arranged to decrease the draft losses and maintain the velocity of the gases through the boiler. The percentage of boiler-heating surface exposed to the radiant heat of the furnace has been slightly increased by this baffling arrangement and the possibility of gas pockets eliminated.

The boiler side walls have been extended up to an elevation that is flush with the tops of the boiler drums, and the spaces between the drums have been filled in with cinder concrete, which construction permits of a perfectly flat surface over the top of each boiler battery.

Mechanical soot blowers have been provided in each boiler. Soot pipes of 12-in. diameter convey the soot by gravity from the soot compartments of each boiler to the first floor of the boiler room. Balanced-draft regulators have been installed on every boiler.

The forced-draft equipment is in the boiler room on the first-floor level and consists of four 75,000-cu.ft. turbine-driven fans, one of which is a spare. Each fan is capable of operating four boilers at 200 per cent of rating. Discharge from the fans is made into a common air duct from which branches are connected to the stoker wind-boxes. The room provided for this fan equipment is separate from the boiler room and adjacent to the turbine room. This arrangement permits the warm air from the generators to be discharged directly into the fan room and there drawn into the fan. The speed of each fan turbine is controlled by the steam pressure, which has been balanced against a column of mercury, whose movements act through a hydraulic pilot-valve system to regulate the fan.

Feed-water heaters of the open type are installed on a gallery above the tops of the boilers and at the north end of the present boiler room, a position which will be central in the boiler room when the extension now

under construction is completed. A storage tank for city makeup water, and to which the bearing cooling water is discharged, is located above the heaters. Condenser hotwell and high-pressure drip returns discharge directly into the open heaters, which are in duplicate. The feed water will be heated to approximately 212 deg. in the open heaters.

Three centrifugal boiler-feed pumps of 500-gal. per minute capacity are now installed. These pumps are in a spacious aisle in the rear of the boilers on the operating floor.

The west side of the boiler-room first floor has been devoted to a spacious shower, a toilet and locker room. The space beneath the boilers and ash hoppers is clear except for the structural-steel building columns. A drainage trench covered with perforated plates has been provided in the first floor under each line of ash hoppers.

The firing aisle is 22 ft. wide and is lighted on the operating floor from continuous saw-tooth sash located over the boilers and also on each side of the overhead bunker. The aisle between boiler batteries is 10 ft. wide.

Turbine-Room Layout

The turbine room, which is 54 ft. wide, 145 ft. long and 66 ft. high, is adjacent to the east side of the boiler room and between it and the switch house. The interior of the turbine room is finished with gray and white glazed-faced brick, the gray forming a dado and border for the plain white panels. There are windows in the east and west walls near the roof and full-length windows in the north and south walls. A skylight 18 ft. wide, extending the full length of the turbine-room, results in a well-lighted and ventilated area.

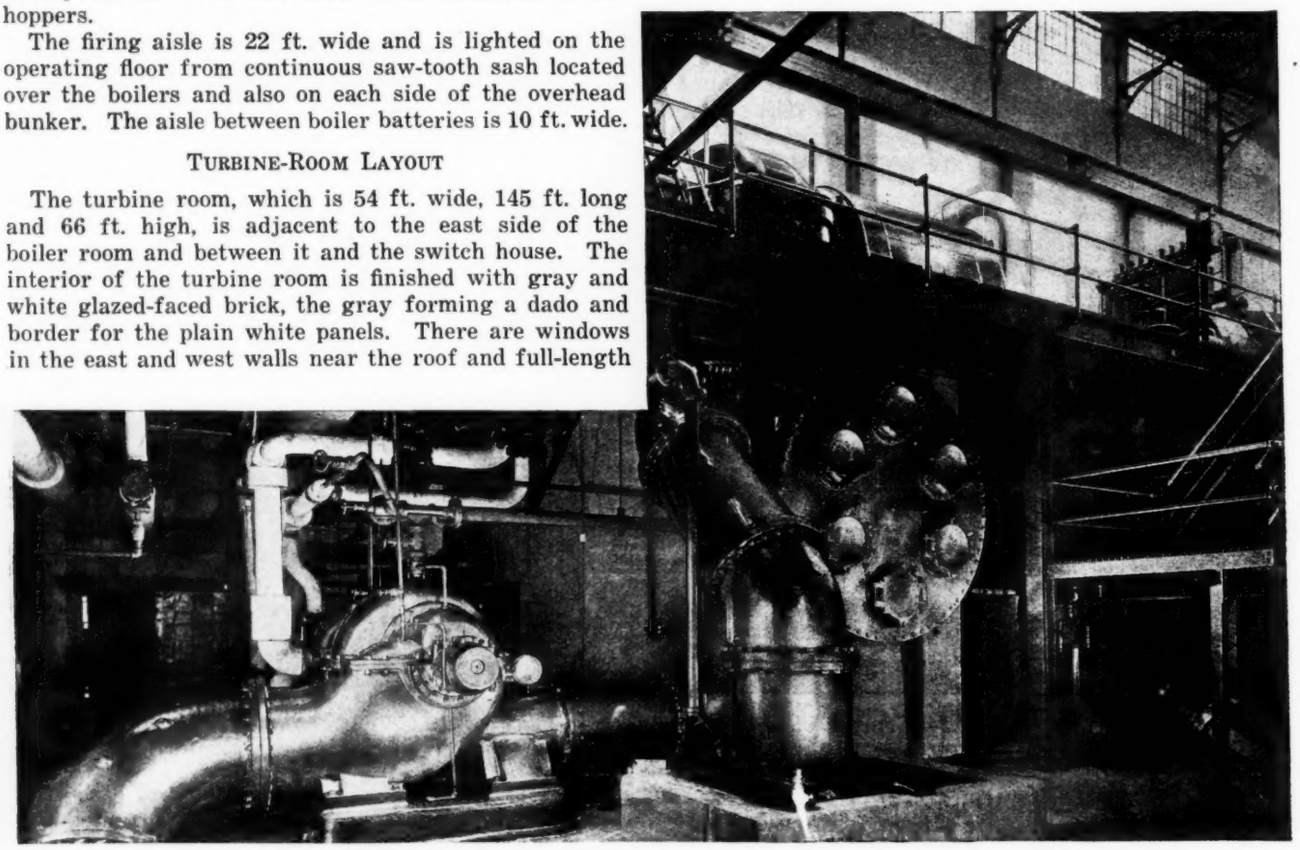


Fig. 4—All condensing and other auxiliary equipment is easily accessible

Three 10,000-kw. three-phase 60-cycle 6,600-volt turbo-generators are now installed. These machines are set at the operating-floor level and mounted on concrete foundations. Each unit is isolated with only a floor of subway grating surrounding it. Walkways connect each turbine to its neighbor, to the boiler room on the west, and to the switchhouse on the east. There is also a stairway from each unit down to its auxiliaries on the first floor.

Two duplex steam and electrically driven 125-volt exciter sets, each of 150 kw. capacity, have been installed on the operating floor at the south end of the turbine room. The location of the exciters is shown in Fig. 1.

The air for the generators is cleaned and cooled by passing it through air washers, which have been provided for each unit. These washers take their air directly from the turbine room.

Referring again to Fig. 1, it will be noticed that a screenhouse has been located at the edge of the seawall, directly over the intake tunnel for the condenser circulating water. Removable trash screens have been provided at the mouth of the intake tunnel and three traveling screens, one for each generator unit, are in the screenhouse. This house has been designed to permit the complete withdrawal of each screen inside this building. The screens are set vertical and the house is heated to minimize ice troubles during the winter months. The intake-well design provides for gates, which completely isolate each screen compartment so that it may be pumped out and cleaned when desired. Additional screens may be installed on the south side toward the harbor line and the screenhouse extended likewise.

The condensing water, after passing through the traveling screens, is drawn from the intake tunnel through 30-in. cast-iron pipes to the condenser circulating water pumps. After passing through the condensers, it is discharged into a common discharge tunnel on the west side of the intake tunnel and adjacent to it. A bulkhead built at the mouth of the discharge tunnel diverts the water from the condensers away from the intake well, thus always insuring a flow of cool water to the condensers.

The condensing equipment for each turbo-generator consists of a two-pass 16,250-sq.ft. surface condenser,

connected to the turbine casing through a copper expansion joint, and supported rigidly on concrete foundations. A 24-in. volute circulating-water pump connected through reduction gears to a steam turbine is installed, also a 4-in. 2-stage turbine-driven hotwell pump. A 10x25x18-in. single-cylinder two-stage, dry-vacuum air pump is also part of condensing equipment.

An oil-filtration system of the partial filtration type with continuous by-pass has been installed in the oil room.

The Switch House

The switch house, which is east of the turbine room, is 33 ft. wide and 147 ft. long. The bus structure room is 33 ft. wide and 95 ft. long. This room contains a double 6,600-volt three-phase bus structure, each phase being kept separate and independent of the others, by concrete housing. On the opposite side of a separating wall from the bus are the high-tension 125-volt direct-current motor-operating oil switches. The potential transformers are beneath the bus opposite the oil switches and the current transformers below the floor. The connections between the generators and the buses and from the buses to the outgoing feeders, the current-limiting reactances and the station control switchboard are on the floor directly below the bus structure.

The switchboard room directly above the bus-structure room is 32 ft. wide and 72 ft. long. From this floor all equipment is remote-controlled. The current for remote-control operation is obtained from a storage battery in the battery room on this floor. A small motor-generator set for charging this battery is floated on the control bus. The emergency lighting system is also connected to this storage battery.

The main connections to and from the oil switches are in fiber conduit incased in concrete, while the secondary and control wiring is in individual conduit, which, so far as possible, is located in the floors and walls.

The switchboard for the control of the station auxiliary power, which is three-phase 60-cycle 440-volt, is on the first floor of the switchhouse. This power is secured from the power transformers stepping down from 6,600 volts to 440 volts, a ratio of fifteen to one.

The transformers from which will be obtained the three-phase 60 cycle 440-volt station power and the 110/220-volt lighting, are immediately outside of the switchhouse and to the south of the main entrance

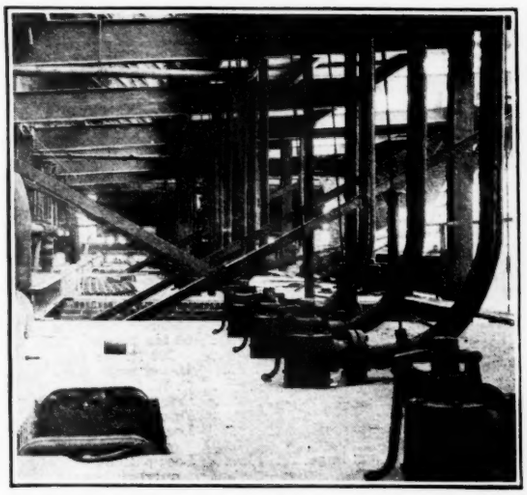


Fig. 5—Boiler tops are well lighted

stairway. The rheostat for grounding the generator neutrals is on the first floor beneath the entrance stairway. It is possible by a system of oil switches to connect the ground resistor to any one generator.

An electric signal system is installed between the main switchboard and the turbine room. There are special panels for control of generators with signal lights for (1) start, (2) stop, (3) stand by, (4) ready, (5) emergency stop, etc. This system is used by the operators to indicate the number of generators desired in operation and when each should be started or stopped and cut in or out.

Westcott & Mapes, Inc., of New Haven, Conn., are the designing and supervising engineers on this project.

DATA ON PRINCIPAL EQUIPMENT IN STEEL-POINT STATION OF UNITED ILLUMINATING CO.

GENERAL

Location of plant	Bridgeport, Conn.
Character of service	Light and power
Capacity, present building, kw.	30,000
Ultimate, kw	100,000
Boiler house, ft.	95x145
Turbine room, ft.	54x145
Switch-house, ft.	33x145
Width of firing aisle, ft.	22
Designing and supervising engineers	Westcott & Mapes, Inc., New Haven, Conn.
General Contractors	Casey & Hurley, Bridgeport, Conn.

BOILERS AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.
Type of boiler	Sectional, water-tube, 3 drum
Number installed	12
Steam-making surface per boiler, sq.ft.	7,546
Steam-making surface per kw. installed, sq.ft.	3.02
Grate area (projected) per boiler, sq.ft.	6—137 and 6—131
Ratio steam-making surface to grate area	55 to 1
Furnace volume, cu.ft.	1,185
Sq.ft. of steam-making surface per cu.ft. of furnace volume	6.36
Cu.ft. of furnace volume per sq.ft. of grate area	8.64
Arrangement of tubes	16 tubes high and 21 wide
Sizes of tubes	4 in. x 20 ft.
Boiler pressure, lb. gage	225
Type of superheater	Integral
Manufacturer	Babcock & Wilcox Co.
Location of superheater	Above first and second passes
Superheating surface per boiler, sq.ft.	981
Ratio superheating to steam-making surface	1 to 7.69
Steam temperature at 200 per cent rating, deg. F	512
Corresponding superheat, deg. F.	115

FUEL

Kind	Eastern run of mine, bituminous coal
Heat value, B.t.u. per lb.	14,000

STOKERS

Manufacturer	American Engineering Co.
Type	Six BA6 Taylors and six CHC6 Taylors
Number per boiler	1
Effective length of BA6 type	10 ft. 10⅞ in.
Effective length of CHC6 type	10 ft. 9 in.
Width of BA6 type	12 ft. 7 in.
Width of CHC6 type	12 ft. 2¼ in.
Projected grate area for BA6 type sq.ft.	137
Projected grate area for CHC6 type, sq.ft.	131
Number of retorts per stoker	7
Pounds of coal burned per sq.ft. of grate area at 200 per cent of rating	35
Stoker drive, 4 vertical steam engines (2 engines for 6 boilers)	7x7 in. Troy engines, chain-driving jackshaft for each row of 6 stokers

Efficiencies in per cent of boiler rating:

Per Cent of Rating	Combined Boiler and Furnace Efficiency
100	75 per cent
150	78 per cent
200	74 per cent

FORCED-DRAFT EQUIPMENT

Manufacturer	Buffalo Forge Co.
Number of fans	4 (3 now installed)
Type	Turbo Conoidal
Capacity per fan, cu.ft. per min.	75,000 at 6 in. static pressure
Drive	133-hp. Terry Turbine with reducing gear.
Draft control	Carrick combustion control system

BOILER-FEED PUMP

Manufacturer	Worthington Pump & Machinery Corp.
Number of pumps	4 (3 now installed)
Type	Jeanesville double-suction centrifugal, 3-stage, 250-lb discharge
Capacity—Each	500 gal. per min.
Drive	135-hp. Terry Turbine

PRINCIPAL EQUIPMENT IN STEEL-POINT STATION OF UNITED ILLUMINATING CO. (Concluded)

HEATERS

Manufacturer	H. S. B. W.-Cochrane Corp.
Number and type	2, Open cylindrical
Capacity, rated, each	300,000 lb. per hour

CHIMNEYS

Number and type	2, radial brick with W. & M. heads
Erected by	Alphons Custodis Chimney Construction Co.
Height, ft.	Above base, 175, above grate, 160.
Inside diameter at top, ft.	12.5
How supported	Concrete base on concrete piles

COAL HANDLING

Type	Belt conveyors
Furnished by	Robins Conveying Belt Co.
Belts from yard storage to bunker	Two, 20-in., 60 ton per hour, 200 ft. per min.
Length of belts and lift	One 311 ft. on centers, 87 ft. lift One 265 ft. on centers, 87 ft. lift
Crushers	Two 24 x 36 in., 2-roll, 60 ton per hr.
Crushers, make	Robins Conveying Belt Co.
Two shaking feeders, make	Robins Conveying Belt Co.
Overhead bunker, capacity and type	800 ton, concrete
Coal distributed in bunker by	2 belt conveyors each equipped with tripper
Furnished by	Robins Conveying Belt Co.
Capacity, etc., each	60 ton per hr., 20 in. x 136 ft., 200 ft. per min.
Coal distributed to boilers by	10-ton weigh larry
Larry furnished by	C. W. Hunt Co.
Yard, coal storage	Present, 75,000 tons Future, 40,000 tons
Method of unloading from barges	Locomotive cranes (temporary only)
Method of reclaiming from storage	Locomotive Cranes (temporary only)
Two locomotive cranes	McMyler Interstate Co.

ASH HANDLING

Ash storage per boiler hopper, cu.ft.	170
Gates (steam operated) per hopper, number and size	2—4x4 ft.
Make	Baker, Dunbar Co.
Two, 95-cu.ft. storage-battery ash trucks	The Baker R & L Co.
Two 100-cu.ft. skip hoists	R. H. Beaumont Co.
Two 7,000 cu.ft. ash bunkers, type	Reinforced concrete

MAIN GENERATING UNITS

Manufacturer	General Electric Co.
Type	Curtis, 9 pressure stages, two-stage velocity wheel in first pressure stage, single-stage velocity wheels other stages
Capacity, each	10,000 kw. at 80 per cent power factor
Number of units	3 (present)
Speed of units, r.p.m.	1,800
Throttle pressure and superheat	200 lb. gage and 115 deg.
Type of generator	A.T.B., 3-phase, 60-cycle, 6,600 volt
Ventilating air	30,000 cu.ft. per min.

Guaranteed performance:

Load, kw.	Lb. of Steam per Kw.-Hr.
5,000	13.95
7,500	13.00
10,000	12.85
12,500	13.10

EXCITER SETS

Type	Combined motor and turbine drive
Make	Terry Steam Turbine Co.
Number, capacity, etc.	Two 150-kw., 1200-r.p.m., 125-volt

SURFACE CONDENSERS

Manufacturer	Worthington Pump & Machinery Corp.
Tube surface, each, sq.ft.	16,250
Sq.ft. of tube surface per kw. of generator rating	1.625
Connection to turbine	Copper expansion joint
Support	Solid

CIRCULATING-WATER PUMPS

Number, each condenser	1
Manufacturer	Worthington Pump & Machinery Corp.
Capacity	16,250 g.p.m. against a 25-ft. head
Drive	General Electric split-case turbines with reduction gears

AIR PUMP

Number per condenser	1
Manufacturer	Worthington Pump & Machinery Corp.
Type	Rotative dry vacuum single, horizontal, two-stage, Laidlow feather valve
Size	10x25x18 in.

CONDENSATE PUMPS

Number per condenser	1
Manufacturer	Worthington Pump & Machinery Corp.
Type	Horizontal two-stage split-case centrifugal
Drive	Terry Turbines

SCREEN WELL AND INTAKE TUNNELS

Screen wells, number	3
Three traveling screens	Chain Belt Co.
Width, each screen	4 ft. 3 in.
Travel	10 ft. per minute

PIPE AND FITTINGS

Furnished and erected by	M. J. Dougherty Co.
High-pressure steam piping (Main and Auxiliary):	
Pipe—Heaviest full card weight, open hearth steel; lap welded above 2 in.	Butt welded below
Joints 4 in. and above	Extra-heavy reinforced Vanstone
Joints 2 in. to 4 in.	Welded flanges
Joints below 2 in.	Screwed
Flanges	Extra-heavy, forged or rolled steel
Fittings	Extra-heavy annealed open-hearth cast steel
Exhaust-Steam Piping:	
Pipe	Standard weight open-hearth steel
Sizes 2 in. and below	Butt-welded
Sizes above 2 in.	Lap-welded
Joints 8 in. and above	Regular Vanstone
Joints 2 in. to 8 in.	Screwed flanges
Joints below 2 in.	Screwed
Flanges	Standard weight, forged or rolled steel
Fittings	Standard weight, cast iron
High-pressure Feed-Water Piping:	
Pipe	Extra-heavy seamless semi-annealed brass (extra heavy iron-pipe size)
Joints	Screwed flanges
Flanges and Fittings	Extra-heavy, cast iron
Low-Pressure Feed-Water Piping:	
Pipe	Standard-weight seamless semi-annealed brass pipe (iron-pipe size)
Joints	Screwed flanges
Flanges and fittings	Standard weight, cast iron
Service-Water Piping:	
Pipe	Extra-heavy genuine wrought iron
Joints	Screwed flanges 2 in. and above and screwed below 2 in.
Flanges and fittings	Standard, cast iron

MISCELLANEOUS EQUIPMENT

No.	Equipment	Type	Size or Capacity	Manufacturer
3	Air washers	Water spray	30,000 cu.ft. per min.	E. B. Badger & Sons Co.
3	Circulating water pumps, for air washer	Centrifugal	200 g.p.m.	Pennsylvania Pump and Compressor Co
12	Soot blowers	Diamond	6 units	Diamond Power Specialty Corp.
1	Station crane	3-motor traveling bridge	30-ton	Pawling & Harnischfeger
1	Air compressor	Low pressure	14x12 in.	The Norwalk Iron Works Co.
1	Oil-filtering system	Partial filtration continuous by-pass system		S. F. Bowser & Co.
1	Combustion-control system	Balanced mercury column		Carrick Engineering Co.
12	Balanced-draft systems			Engineer Co.

MISCELLANEOUS EQUIPMENT AND MATERIALS

Equipment	Manufacturer
Feed-water regulators	Northern Equipment Co.
Safety valves	Consolidated Safety Valve Co
Blowoff valves	Yarnall-Waring Co.
Blowoff cocks	Everlasting Valve Co.
Boiler non-return valves	Edward Valve and Mfg. Co.
High-pressure steam gate valves	Jenkins Bros.
High-pressure steam globe valves	Jenkins Bros.
High-pressure steam globe valves	Edward Valve and Mfg. Co.
High-pressure water gate valves	Jenkins Bros.
Low-pressure steam and water gate valves	Chapman Valve Mfg. Co.
Low-pressure steam and water gate valves	The Lunkenheimer Co.
Steam-flow meters	(Pending decision)
Recording and indicating gages	Bristol Co.
Recording and indicating gages	Ashcroft Mfg. Co.
Recording and indicating thermometers	Bristol Co.
Recording and indicating thermometers	Taylor Instrument Co's.
Master steam gage	Ashton Valve Co.
Load indicator	(Pending decision)
Draft gages	Bailey Meter Co.
Copper expansion joints	Benj. F. Shaw Co.
Atmospheric relief valves	Edward Valve and Mfg. Co.
Operating and control mechanism for motor operated valves	Payne Dean, Ltd.
Boiler settings	Casey & Hurley
Firebrick and clay	McLeod & Henry Co.
High-temperature cement	McLeod & Henry Co.
High-temperature cement	Seth Lee Fire Brick Co.
High-temperature cement	H. P. Woodbury Co.
Solid furnace blocks	McLeod & Henry Co.
Perforated furnace blocks	Bernitz Furnace Appliance Co.
Perforated furnace blocks	Drake Non-Clinkering Furnace Block Co.
Smoke flue and air ducts	McCathron Boiler Works
Pipe covering (85 per cent Magnesia)	Johns-Manville, Inc.
Flue covering	Nightingale & Childs
Structural steel	Geo. F. Watts Corp.
Steel sash and sash operators	David Lupton's Sons Co.
Skylights	Wm. V. Dee Co.
Gratings for walkways	Irving Iron Works Co.

An Old-Time Engineer's Rule

Power was recently given an opportunity to inspect and photograph a most interesting old brass rule which in all probability was the pocket companion of some British engineer of an earlier era. A general view of this rule, which was brought to the attention of *Power* by S. C. Page, Endicott, N. Y., and loaned by I. B. Payne, Horseheads, N. Y., is shown in Fig. 1.

It is 24 in. long, $1\frac{3}{4}$ in. wide, $\frac{1}{16}$ in. thick, and is made of four 6-in. sections connected by home-made piano hinges. In fact the whole rule is evidently a home-made affair, as evidenced by the irregular manner in which it is stamped. It is thought that some of the readers of *Power* may enjoy puzzling over the rather mysterious markings on this rule.

The face opposite that shown in Fig. 1 is graduated in inches, halves, quarters and eighths, as shown in the two sections of Fig. 2. The numbers on the two sides of the inch and half-inch marks are supposed to be the areas and circumferences of circles having the indicated diameter. For example, according to the rule, a $7\frac{1}{2}$-in. circle has an area of 44.10 sq.in. and a circumference of 23.42 in. The fact that these figures differ somewhat from the correct values indicates that they were computed by some approximate rule.

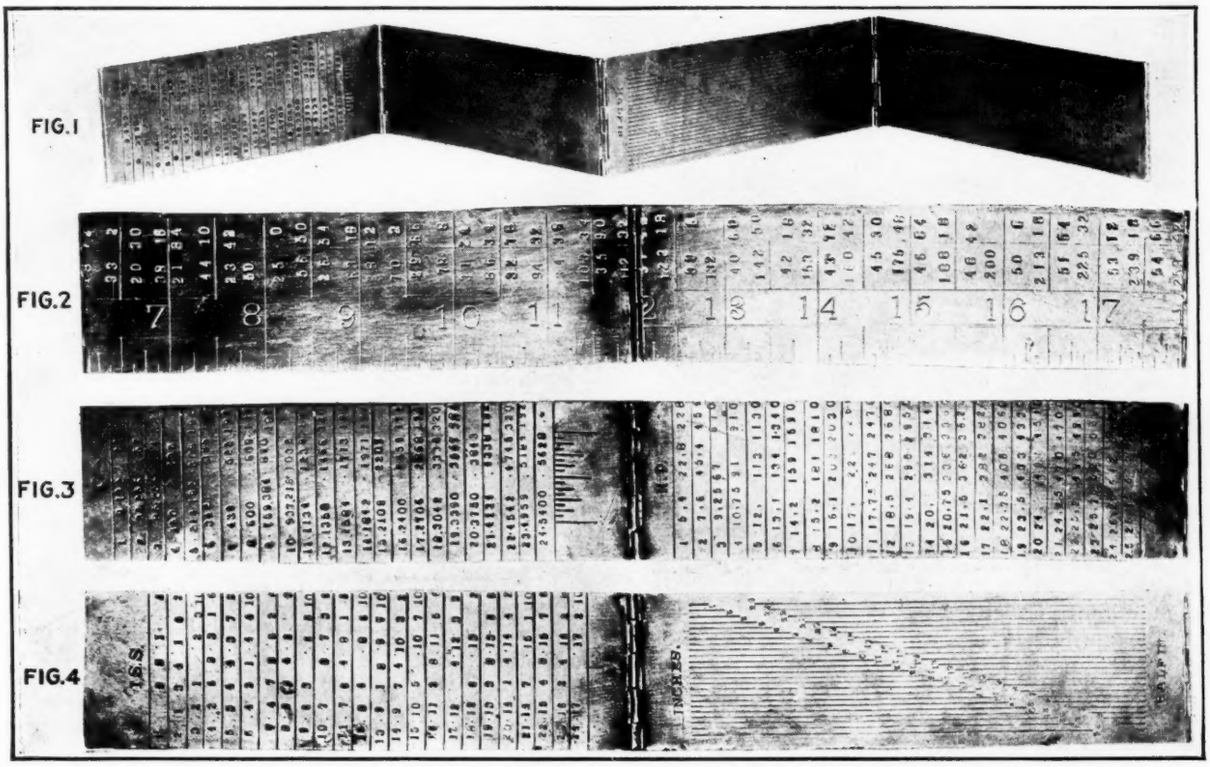
Fig. 3 is a closer view of two sections of the face shown in Fig. 1. The left section seems to consist of several columns of figures, the first giving the whole numbers from 1 to 24, and the other columns some sort of a constant under the heading *"C."* The figures in the second column are approximately 9.3 times the square of those in the first, and might conceivably represent some sort of a horsepower constant based on the bore of an engine. No attempt will be made to explain the remaining figures in this section.

Similar columns are given on the right-hand section of Fig. 3 under the heading *"H.P."* The first column contains the whole numbers from 1 to 25. The second column is approximately 5.4 times the square root of the first column. In the third column the figures are practically 22.8 times those in the first, and those in the fourth are 228 times those in the first.

Turning next to Fig. 4, the initials *"I.S.S."* will be found at the head of the left-hand section, along with several columns of figures, the first containing the whole numbers from 1 to 25. No attempt will be made to explain the other figures in this section.

The next section is marked "Inches" at one end and has a set of parallel lines $\frac{1}{16}$ in. apart and ranging from $\frac{3}{16}$ to $4\frac{3}{8}$ in. in length. These lines, which increase in length by uniform steps, are numbered from 1 to 24. On the opposite end of this section is a similar set of lines with the general heading "Half In." These lines, which are also numbered from 1 to 24 and increase by uniform steps, range in length from $\frac{1}{8}$ in. to $4\frac{1}{4}$ inches.

With these few clues some reader may play the part of Sherlock Holmes and fathom the mysteries of this old rule. It would be interesting to learn the purpose of the various constants and graduations and to see how they measure up with present-day engineering methods. In one respect, at least, we have progressed. No modern engineer would lug around a pound of brass in place of a notebook.



Figs. 1 to 6—Old-time engineer's rule is a home-made affair of brass with mysterious markings.

Fig. 1—General view of the back side. Fig. 2—Two sections of front side, showing figures for areas and circumferences of circles. Fig. 3—Two sections of back side showing tables for *"C"* and *"H.P."* Fig. 4—Remaining two sections of back side showing tables for *"I. S. S."* and special scales of "Inches" and "Half-in."

Reconnecting Direct-Current Armature Windings—Lap Wound Armatures

Two-Layer Lap Windings as Used on Drum-Type Armatures—Armature-Winding Diagrams Explained—Single and Double Windings—Use of Equalizer Connections and How They Are Made

By A. C. ROE
Shop Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company

IN MODERN direct-current motors and generators the armature winding used is generally the two-layer drum type, the Gramme ring winding being practically obsolete. Two-layer windings for direct-current machines can be divided into two distinct types—lap (parallel or multiple) and wave (series or two-circuit). In the following discussion the terms lap and wave will be used to designate the type of windings. A two-layer drum winding gets its name from the arrangement of the coils around the outer periphery of the core, as in Fig. 3, in contradistinction to the ring winding, where the coils are wound around a ring core, as in Fig. 1. In the modern drum-type winding the coils are placed in slots on the outer periphery of the core, Figs. 2 and 3, which allows making a much more substantial job than was possible with the smooth core construction, where the coils were wound on the surface of the core and held in place by banding wire. Placing the coils in slots allows bringing the core nearer the polepieces, and the coils are much better protected against injury. In almost all windings for direct-current machines the two-layer type is used; that is, one side of two different coils are in the same slot. For example, in Fig. 2, the bottom side of coil 12 and the top side of coil 18 are in slot 12, counting from the left. It will be seen from the figure that the left-hand sides of the coils fall above the right-hand sides, making the winding two-layer not only in the slots but at the ends of the coils. This allows forming the coils so that when they are placed on the core they fall together in such a way as to form practically a continuous surface on the outer periphery of the armature.

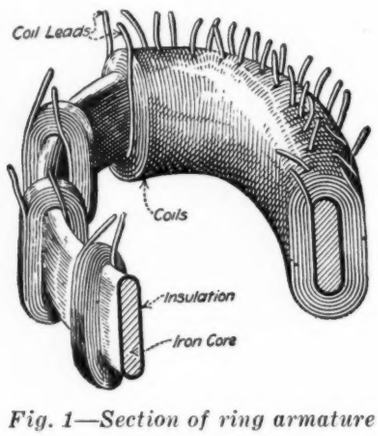


Fig. 1—Section of ring armature

Meaning of the Term "Lap" as Applied to Windings

The term "lap," as applied to a direct-current armature winding, is derived from the way the coils overlap each other. How the coils in the same circuit overlap each other will be understood by following out a circuit in Fig. 2. Starting at segment 13 and following through coil 13, the circuit returns to segment 14, then

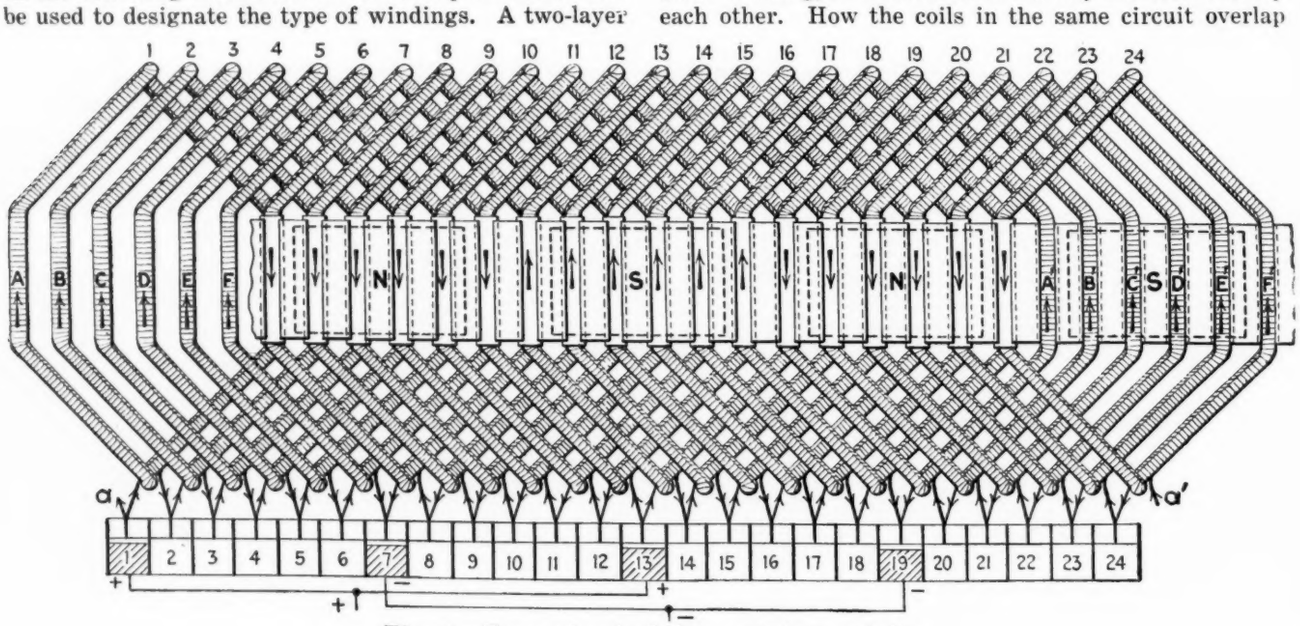


Fig. 2—Four-pole single-lap armature winding

through coil 14 which laps back adjacent to coil 13. After passing through coil 14, the circuit is through coil 15, which laps back adjacent to coil 14 and so on through the winding until the circuit is completed on segment 19.

One of the distinguishing features of a lap winding is that the coil leads bend in toward the center line

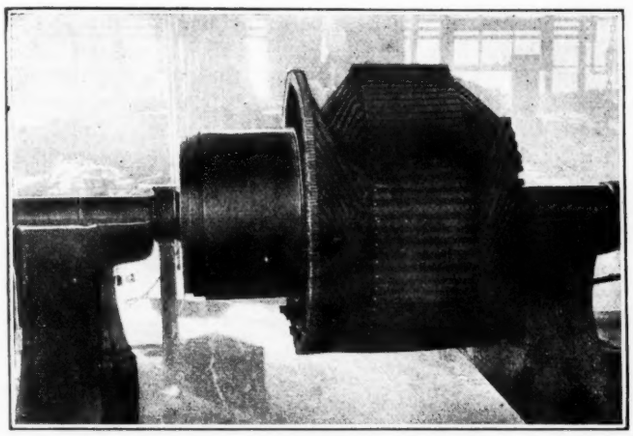


Fig. 3—Armature partly wound with lap winding

of the coil. A single-lap winding will have as many paths or circuits as there are poles in the machine and will also require as many groups of brushes as poles. This type of winding can have any number of commutator bars, odd or even, but the voltage between bars must be kept to a safe value.

Laying Out Armature Windings

To the uninitiated, armature-winding diagrams may appear somewhat complicated, but in fact they are as simple as most any other electric circuit, when the method of laying them out is understood. Fig. 2 is one of the most complete methods of laying out a winding, but is limited in its use on account of the work involved in making the drawing. It represents such a winding as shown, partly completed, in Fig. 3, laid out flat, and the similarity between Figs. 2 and 3 is apparent by a comparison. In Fig. 2, if the diagram were rolled up to form a complete winding, sides of coils *A*, *B*, *C*, *D*, *E* and *F* would fall in slots *A'*, *B'*, *C'*, *D'*, *E'* and *F'*, and lead *a* connect to lead *a'*, making the winding take the form as if on a round core.

Instead of using an elaborate diagram as in Fig. 2, the winding may be represented by straight lines as in Fig. 4. In this case the dotted lines represent the under sides and the full lines the top sides of the coils. If this diagram were rolled up so as to form a ring, coil sides *A*, *B*, *C*, *D*, *E* and *F* would fall alongside of coils *A'*, *B'*, *C'*, *D'*, *E'* and *F'*. Leads *a* and *a'* would connect together to complete the circuit through the winding. Another method of laying out a winding diagram is that shown in Fig. 7. All three windings, Figs. 2, 4 and 7, are the same and the circuits trace out in them the same. For example, start from the brush on segment 13 and follow through the top half of coil 13 around to segment 14, which can be done on all three diagrams. From segment 14 the circuit is through coil 14 to segment 15 and then through coils 15, 16, 17 and 18 to the brush on segment 19, as indicated, by the arrowheads. There is another circuit from segment 13, through coil 12 to segment 12, then through coils 11, 10, 9, 8 and 7 to the brush on segment 7. There are two other circuits from the brush on segment 1 to the brushes on segments 7 and 19, all of which are indicated by arrowheads.

As there is only one path between any two adjacent brushes, the windings Figs. 2, 4 and 7 are known as a single-lap winding. This winding as laid out is good for a four-pole machine; that is, the coils are spread one-quarter of the armature periphery, or in this case into slots 1 and 7, spaced 6 slots. On a six-pole armature the coils would span approximately one-sixth of the armature's periphery, and for a single-lap winding there would be six circuits through the coils and six brushes on the commutator, as in Fig. 8. This relation holds true for all single-lap windings. For example, if an armature were wound for 12 poles, there would be 12 circuits in the winding and there must be 12 groups of brushes on the commutator. The chief difference in diagrams, Figs. 2, 4 and 7, is that the coils in Fig. 2 are shown made up of a number of turns taped together before being placed in the slots, where the winding diagrams Figs. 4 and 7 are shown with a single turn, but this does not in any way affect the circuits

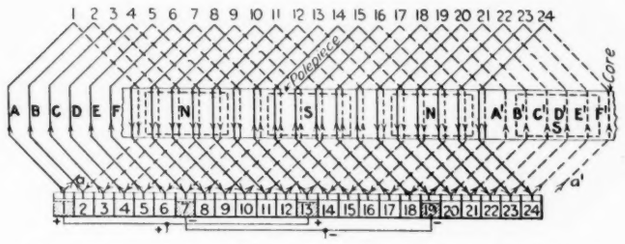


Fig. 4—Same as Fig. 2, but laid out in single lines

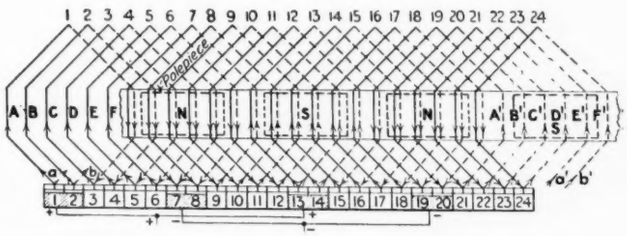


Fig. 5—Winding Fig. 4—connected double-lap

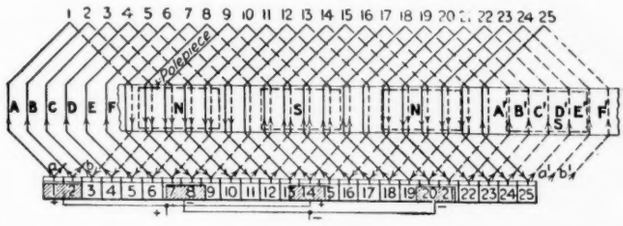


Fig. 6—Four-pole double-lap winding having 25 coils

through the windings or the connections to the commutators.

Looking at the armature facing the commutator end, in Figs. 2 and 4, the top halves of the coils are on the left-hand side, and the winding is termed left-handed. If the top halves of the coils are on the right-hand side of the observer, as in Fig. 3, the grouping is called a

right-hand winding. This also applies to wave windings. The windings Figs. 2, 4 and 7 are also called singly re-entrant windings, since after starting from a given segment in the commutator and following through all the coils, the winding closes on itself. For example, in Fig. 2, starting from segment 1 and passing through coil 1, all the coils can be followed through in a single circuit and end on segment 1; that is, coils 1, 2, 3, 4, 5 to 24 can be followed through in a single circuit and return to the starting point on segment 1.

Double Re-entrant Windings

A double re-entrant winding closes on itself after passing through half the coils. For example, the winding Fig. 5 is connected double-parallel. In this winding there are two paths between any two adjacent brushes and the brushes have to be wide enough to cover at least two segments. Starting from the brush on segments 1 and 2, the circuit is through coils 1 and 2 in parallel to segments 3 and 4, and then through coils 3 and 4 in parallel, then coils 5 and 6 to the brush on segments 7 and 8. If one circuit only was followed through, say, from segment 1, this would include coils 1, 3 and 5 ending on segment 7, on three coils in series. In Figs. 2, 4 and 7 there is only one circuit between adjacent brushes and each circuit has six coils in series, therefore will be good for double the voltage of the winding Fig. 5.

The winding Fig. 5 is not only a double-lap winding, but it is also doubly re-entrant; that is, one-half of the coils form a closed circuit on themselves. Starting from segment 1, a circuit is through coils 1, 3, 5, etc., to 23 and the a' terminal of coil 23 connects to a on segment 1, thus closing the circuit. A similar condition is found by starting from segment 2; the circuit is through coils 2, 4, 6, etc., to 24, and b' terminal of this coil connects to b terminal on segment 2, which closes the circuit. Therefore it is seen that the coils form two closed-circuits on the armature and the winding is said to be doubly re-entrant.

All single windings are singly re-entrant. With a double lap winding, which has twice as many paths as poles, as in Fig. 8, the winding will be doubly re-entrant if there are an even number of commutator bars and coils, and singly re-entrant if the number of coils and bars is odd, as in Fig. 6. In Fig. 6 the winding has 25 coils instead of 24 as in Fig. 5. The winding is connected double-lap, and in tracing the circuits from brush to brush it will be found that they are the same as in Fig. 5. However, if the circuit is traced through the winding as a whole, it will be found that all coils can be passed through before the winding closes on itself. For example, starting from segment 1, the circuit is through coils, 1, 3, 5, 7, etc., to coil 25 and terminal b' to b on segment 2 and then through coils 2, 4, 6, etc., to 24 and then to a' and a, ending at the beginning on segment 1. Since all the coils can be traced through before the winding closes on itself, it is called a singly re-entrant winding.

In connecting the coil leads to the segments Figs. 2 to 4, they connect to adjacent segments; that is, the leads of coil 1 connect to segments 1 and 2. This is the way that all single-lap windings are connected. In the double-lap windings Figs. 5 and 6, the coil leads are connected two segments apart; that is, coils 1 connect to segments 1 and 3, and this is the chief difference in the connection for a single- and a double-lap winding.

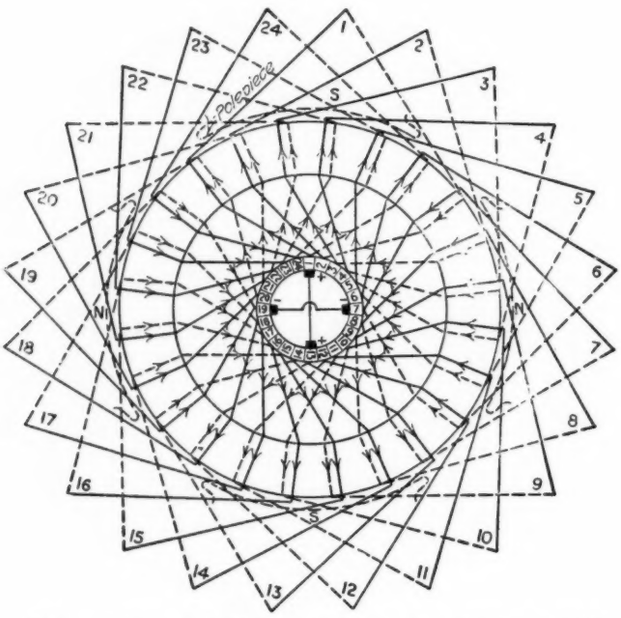


Fig. 7—Same winding as in Fig. 2, but laid out with single lines and continuous

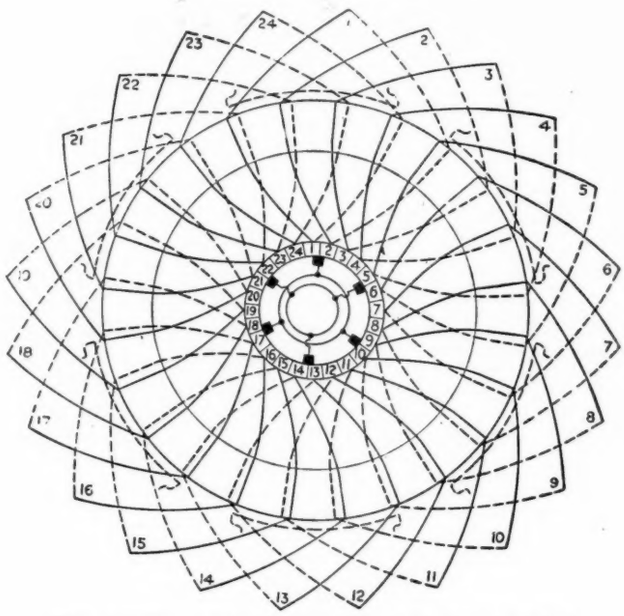


Fig. 8—Same winding as Fig. 7, but connected for 6 poles

Use of Equalizer Connections

Should the armature for any reason not be properly centered between the polepieces of a multipole machine, the flux density in the air gaps will be different and the voltage generated in the groups of coils in the larger air gaps will be less than that for the coils in the smaller air gaps, where the flux will be more dense. This unequal potential in different parts of the armature will cause circulating currents between the different groups of brushes, with its resulting bad effects, unless means are provided to take care of this condition. These circulating currents cannot be prevented

from flowing in the windings, but they can be prevented to a large degree from flowing between the different groups of brushes by the use of equalizer connections. These connections are put on the back of the winding or on the commutator and connect points of the winding that are theoretically at the same potential. The armature will be completely equalized if all the segments on the commutators that are at the same potential are connected together. In a 4-pole machine commutator segments that are exactly 180 mechanical degrees apart are theoretically at the same potential. In a 6-pole machine segments that are 120 deg. apart and in an 8-pole machine segments that are 90 deg. apart should be at the same potential For example, in Fig. 7, segments 1 and 13 are 180 deg. apart and may be connected together permanently with an equalizer connection. This would also be true of segments 7 and 19, 4 and 16 or 10 and 22, or any other two segments 180 deg. apart. Fig. 9 shows an 80-bar commutator with the equalizer connections made to 50 per cent of the segments, and Fig. 10 is a photograph showing equalizer connections in place at the back of the commutator.

Number of Equalizer Connections

When rings are used on the back end of the armature, the least number of connections would be one ring for each pair of poles and one tap from the winding every two pole spaces apart on the armature. On a 14-pole machine there could be a minimum of 7 rings, with 7 taps on each ring, or a total of 49 taps. Ring No. 1 would have the taps spaced, total number of bars divided by 7, apart, or assume an armature with 245 bars, 14-pole seven rings, then $245 \div 7 = 35$. Ring one would connect bars 1, 36, 71, 106, 141, 176, 211, and adding the pitch 35 to 211 gives 246, which is bar one. This proves that the taps are equidistant. Since there

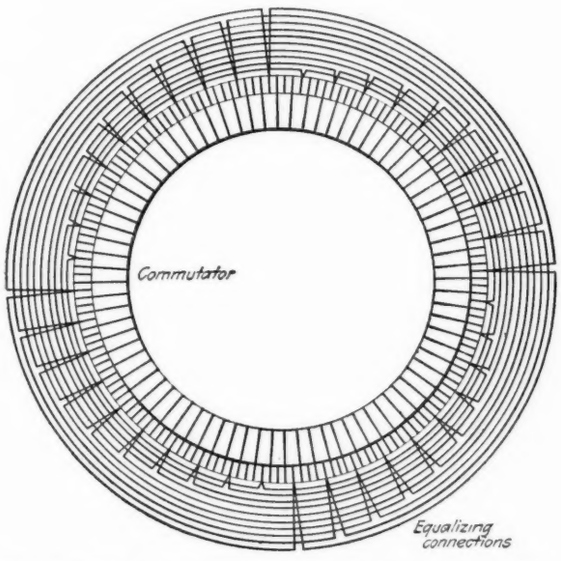


Fig. 9—Eighty-segment commutator with equalizer connections

are 49 taps, these will be $245 \div 49 = 5$ bars apart, or on ring No. 2, which would have seven taps also, the first tap would be to bar 6 and the other taps to bars 41, 76, 111, 146, 181, 216; ring three would start at bar 11, ring four at bar 16, five at 21, six at 26, and seven at 31.

It is the usual practice to use approximately 30 per cent of the total cross-connections required for complete equalization and make the cross-section of the rings and connections, about 50 per cent of the armature coil cross-sections. In lap-wound armatures with cross-connections the total number of bars must be a multiple

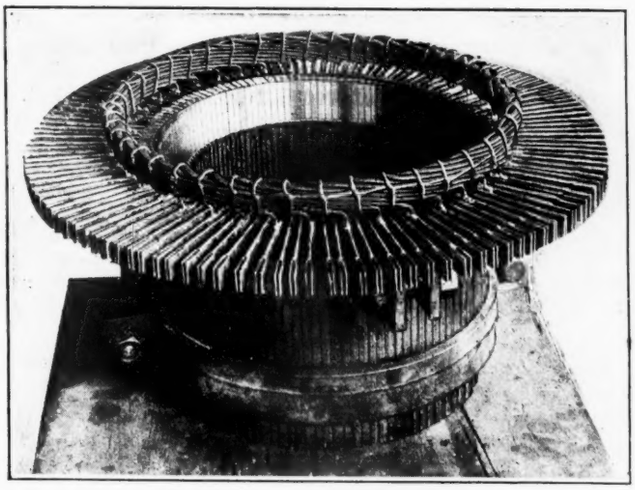


Fig. 10—Shows how equalizer connections are connected to back of commutator

of the number of pairs of poles, so that there will be an equal number of coils in each circuit. The insulation used on the cross-connections is generally two layers of half-lapped 0.007 cotton tape, or one layer empire tape, 0.008, and one layer 0.007 cotton tape, all half lapped.

Increasing Speeds of Ammonia Compressors

By J. H. H. Voss

The speed of a compressor is limited by the piston travel, which ranges from 300 to 550 ft. per min. in ammonia compressors. With a long stroke, usually twice the cylinder diameter, the number of revolutions per minute is small. In an 18-in. diameter by 36-in. stroke compressor the piston speed at 80 r.p.m. is 480 feet per minute.

This same speed prevails in a compressor that has 18-in. bore but only an 18-in. stroke and turns at 160 r.p.m. The latter machine is called a high-speed compressor but in fact is only a *short-stroke machine,* for the piston travel is but 480 ft. per min., the same is in the long-stroke machine. The short-stroke high-speed machine has the great advantage that it can be directly connected to highly efficient prime movers such as electric motors, oil and steam engines.

Having the same piston travel, both slow- and high-speed compressors require the same effective valve area; the difference is that for high speeds low valve lifts prevail, so that either more or larger valves must be used than are required in slow-speed machines. This is the point that calls for careful consideration in the design of the cylinders.

The inlet valve area should be at least 8 per cent of the cylinder area and the discharge area at least 6 per cent. The analysis shows that the valve areas of any

machines are from 40 to 60 per cent short of the minimum valve area suggested.

Small valve areas cause cylinder heating and excess cylinder pressure, with corresponding waste of power. How this happens is best shown by taking indicator diagrams together with temperature readings. Diagrams taken with increasing discharge temperatures show that with low temperatures the excess pressures on both suction and discharge valves are small, but that with increasing temperatures the excess pressure increases greatly.

In horizontal slow-speed compressors with heavy poppet valves, the cylinder pressure is often very high, especially if there is only one suction and one discharge valve at each end of the cylinder. Such machines were originally designed for a small number of revolutions, and afterward their speed was increased without increasing the valve area. Take for instance a 16½x30-in. machine operating at 50 r.p.m. and designed with one suction and one discharge valve in each cylinder head to give a gas velocity of about 5,000 ft. per min. for the suction and 6,000 ft. per min. for the discharge. In order to meet competition the speed of the machine was increased to 65 r.p.m., but the valve areas were not increased. It was found that the machine operated satisfactorily even though the gas velocity was about 6,500 ft. per min. for the suction and 7,800 ft. per min. for the discharge valve. That the cylinder pressures were higher than before was not called to anyone's attention.

After the machine had worked for about ten years, the plant was electrified and the speed of the compressor was increased again. This time the speed was 85 r.p.m. and still the machine worked without distress. Naturally the valves were noisy, for the gas velocity was now 8,500 ft. for the suction and 10,000 ft. for the discharge valves and the excess cylinder pressure about 22 lb. At such high gas velocities the valves cannot function properly and there is great danger of valve breakage. To make a cylinder like this safe, the heavy poppet valves should be replaced by light valves. In cylinders below 11 in. in diameter the valve ports often are large enough to make this change and use only one suction and one discharge valve in each cylinder head. A horizontal ammonia compressor with two suction and two discharge valves in each cylinder head can easily be changed over to the light valves, as the four pockets will give ample valve area.

Blade rubs is the most common trouble in turbines with small clearances and is of two classes. One, when the revolving blades rub the stationary element, is known as a cylinder rub. The other, when the stationary blades rub the shaft, is known as a spindle rub. In the former case the greater mass of metal allows a quicker dissipation of the suddenly generated heat and there is less chance of trouble than in the case of a spindle rub where a high local temperature is generated in the shaft, resulting in shaft deflection. In either case, if the cause of the rubbing is not removed, or if the turbine is kept in operation because the rubs are not detected, the trouble may become cumulative in its character and blades be dislodged and wedged between the two elements. This throws the shaft out of line and may lead to serious trouble.

Steam Boilers

A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues

51. Many water-tube boilers containing from 900 to 1,200 sq.ft. of heating surface, are equipped with a 2½-in. blowoff, connected to the bottom of the mud drum. These boilers are guaranteed for a working pressure of 160 lb. If the gage registered that amount, would you attempt to blow down the boiler for the purpose of removing sediment, and if so would you open the blowoff valve wide, as is recommended by some textbooks?

No. A blowoff valve of the screw type should never be opened more than two revolutions under the conditions mentioned. The total quantity of water in the boiler is so small and the quantity discharged through the 2½-in. pipe under the high pressure is so great, that it is unsafe to open the valve wide; it might be impossible to get it closed in time to prevent the water level from falling below the safety point.

52. On a cross-drum water-tube boiler do you consider it necessary to have a reinforcing sheet for the steam tubes and circulating nipples?

The drums are made up of two sheets. The seams are of the butt and double-strap type. The entrance of both sets of tubes is through the center of the seams, and the seams are double-riveted. The covering straps are, therefore, the reinforcing sheet.

53. Where should the longitudinal seam on the cross-drum water-tube boiler be located with respect to the gas discharges?

The location is unimportant. Both seams are exposed to the furnace gases, but at this point the temperature is so low as to make this feature quite unobjectionable.

54. Why are the main steam openings placed in the heads of cross-drum B. & W. type boilers instead of in the top of the drum, when it is considered better practice to connect the main steam pipe at the greatest possible distance from the surface of the water?

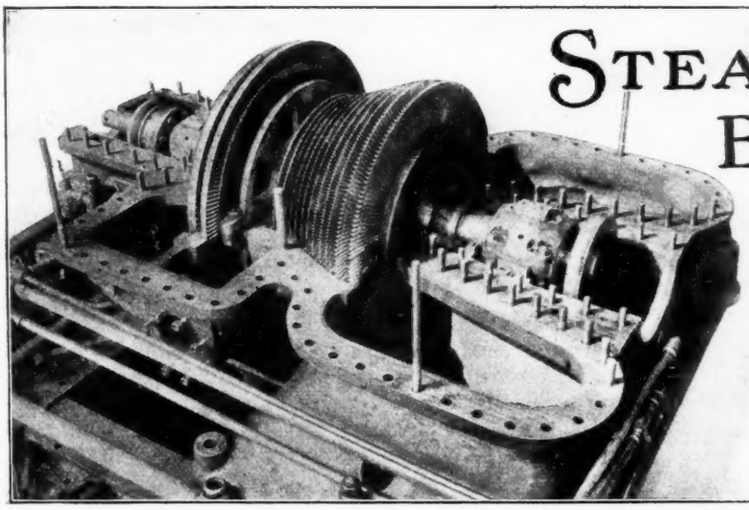
The object in building B. & W. cross-drum boilers is to produce a boiler with a total amount of heating surface in excess of the heating surface of the standard-type boiler occupying the same headroom and other general dimensions. This being so, it follows that the steam connection must be taken from the end of the drum rather than from the top, since otherwise no gain would be made in headroom.

55. A horizontal-tubular boiler is 54 in. in diameter. The total distance from the top of the tubes to the highest point of the shell is 20 in. What is the area of the surface that must be braced? How would you calculate the area of this segment?

The area is 519 sq.in. Divide the diameter of the circle by the height of the segment, less 5 in. Subtract 0.608 from the quotient. Extract the square root. Multiply the square of the height of the segment less 5 in., by 4, and divide by 3. Multiply this quotient by the root already determined. The product is the area in square inches to be braced.

56. Why is a dry pipe preferable to a steam dome?

Dry pipes furnish steam with no greater percentage of moisture than that furnished by steam domes without the additional hazard of a dome explosion.



Steam Turbine Blading

Some Impulse Types

Reaction blading will be discussed in succeeding articles. Impulse types in commercial use present many variations. Features of impulse blading developed by the Moore Steam Turbine Corporation, Westinghouse Electric and Manufacturing Company, and the Terry Steam Turbine Company are here described.

DOVETAIL moving blade fastening, as employed by the Moore Steam Turbine Corporation, presents two interesting features: The shroud-ring element, instead of being made up of a number of small or large sections, is here utilized as one continuous band. This is designed to assist in holding the buckets in place by acting against centrifugal force in case of a disturbance due to an abnormal cause, also adding to blade rigidity. Besides, all blades and spacers are forced together in the slot, so as to form a rigid structure. The disk and blading, therefore, conform to a continuous, rigid mass, with local vibration restrained to the maximum extent.

The blades and spacers are separate from one another as in Fig. 1. These, however, are inserted at only one point in the wheel instead of at a number of points. The blades and spacers are entered in the single opening shown at the left, Fig. 2, and moved into place on the periphery of the wheel. As the blades are assembled, it is possible to force these together under pressure, so that they tend to form one compact mass. The opening in the rim where blades are entered is then plugged and brazed. The shroud ring, Fig. 3, is brazed to the blades as well as being joined by brazing where the two ends come together, so that it represents one continuous integral ring.

The blades are carefully gaged for the exact distance between and also for vertical alignment. After the shroud ring is welded in place, the complete wheel is carefully balanced. Drop-forged steel is used for multi-velocity disks and open hearth for those of the Rateau type.

A non-corrosive alloy "cupro nickel," is employed to withstand corrosion and high temperatures. Another desirable quality is the fact that the metal has somewhat of a slippery surface for the purpose of presenting less friction to the passage of steam than other known materials.

Blading for Westinghouse Turbines

Blading for small impulse turbines of the Westinghouse type is shown in Fig. 5. Buckets of special steel are drop-forged, which produces a hard enduring surface. All sizes are made with integral shroud rings, so that each blade forms a complete unit including shroud.

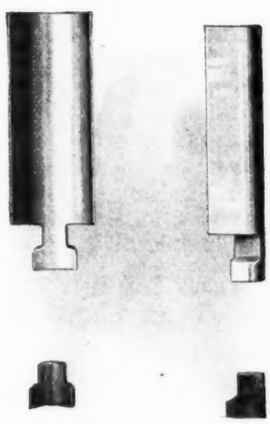


Fig. 1—Blades and spacers

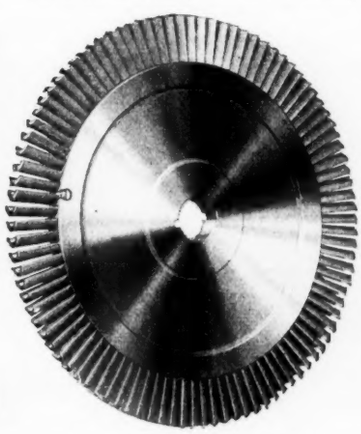


Fig. 2—Blades entered at slot

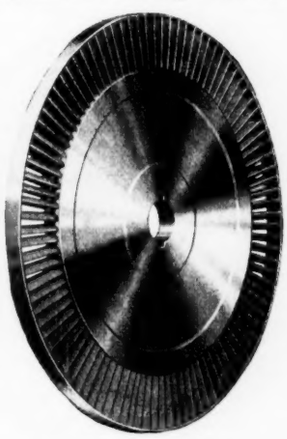


Fig. 3—One-piece shroud

The shroud-ring element or ledge, which is at the top of the blade shown to the left in Fig. 5, locks against the adjacent surface of the blade at each side, so that a continuous shroud-ring surface is formed. This ledge may be all on one side of the blade, as shown in Fig. 5, when the vanes are milled from bar stock. It may be partly in the front of the blade and partly at the back when these are drop-forged. Blades of this character are shown in Fig. 4. These are characteristic of large combined impulse and reaction units.

When the height of the blade is less than 1¼ in., no attempt is made to tie the tops of the blades together. When the blade length is greater, however, the tops are lashed together by brazing or silver soldering a steel strip in a groove turned in the tops of the blades. This groove is shown in Fig. 4, with the lashing pieces in place. These strips are comparatively short, usually

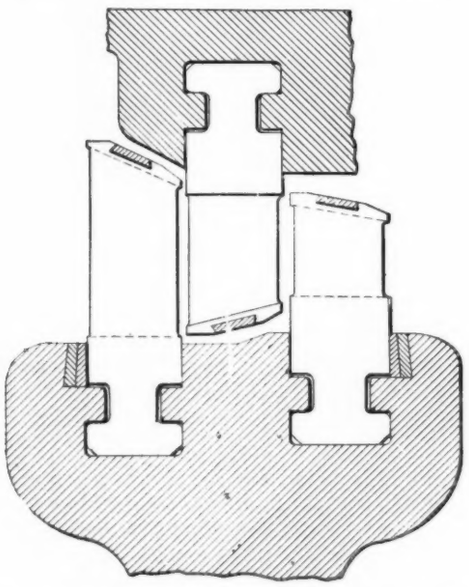


Fig. 4—Wedges rigidly fasten impulse blades

8 or 10 in. long, so that blades are tied together in groups rather than in a complete circle.

In turbines where only one row of blades is fastened to a disk, pins are used, as in Fig. 5. With a double row, or Curtis stage, in which one disk carries two rows of blades, as in the blades shown at the left of the head-

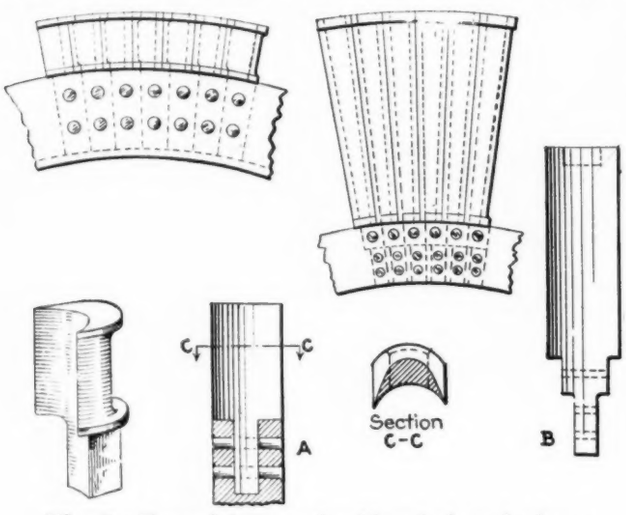


Fig. 5—Forged type and soldered shroud pieces applied to riveted blades

piece of this article, fastening is by means of dovetails and wedges, as in Fig. 4. The pins, Fig. 5, have a driving fit in both disks and blades, so that the holding power is that of perfect double shear. These pins must be located accurately on the center line of gravity of the blade, in order to take the radial pull of centrifugal force. Blades or fastenings are ordinarily proportioned so that they will shear off at about twice full speed. In the larger sizes of blades, double shanks are used for the purpose of accommodating a sufficient number of pins, as at *B* Fig. 5. The pin-holes in the disk are countersunk slightly at each end into which the pins are riveted. This makes end motion of the pins impossible in case of abnormal conditions and yet allows the pins to be driven out when desired.

In order to obtain accurate fastening of the blades, the disk is first drilled by means of a jig, which accurately divides the circle into the desired number of spaces for the pins. These drillings are slightly countersunk as before mentioned. One blade is then put in the rotor and located accurately in a radial position and also in regard to the drilled holes in the disk. These fixtures locate the blade shanks in proper relation to the holes already drilled in the disk. The blade shank is then drilled by using these holes as jigs. This is pos-

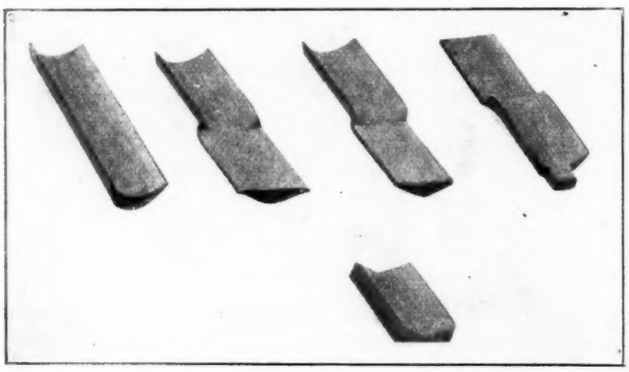


Fig. 6—Stock pressed into a blade

sible from the fact that the tongue of the blade fits in a slot turned in the disk, as shown in Fig. 5 at *A*.

Blades at 6- or 8-in. intervals apart are thus accurately located and pinned to the disk by drilling through the disk holes. After this the remaining blades are filled in between and drilled and pinned as before. The pins are riveted over slightly on the head, after this work is done.

In cases where a lashing strip is used, the entire disk is mounted in a lathe, and the space for this lashing piece is machined out. The lashing piece then is fastened with either silver solder or by brazing, producing a rigid structure.

Terry Company Builds Three Distinct Types

The Terry Steam Turbine Co. builds three distinct types of wheels: The multiple-velocity Terry type, a one-piece wheel with integral buckets recessed in the periphery as in Fig. 7; a multiple-velocity action type containing two or three rows of radial buckets, commonly known as the Curtis type; and a single-pressure-stage type with one row of radial buckets, called the Rateau type. The construction of the Terry type may perhaps be more easily understood from an explanation of its operation. The steam issuing from an expanding nozzle, Fig. 7, at high velocity, enters the side of the wheel bucket, in which its direction is reversed 180 deg. As this single reversal uses but a portion of the available energy, the steam is caught in a reversing chamber and returned again to the same wheel. This process is repeated several times, giving the desired multiple velocity effect, until all the practically available energy has been utilized.

This principle, which returns the steam several times to the same row of moving buckets, makes possible the use of the steam in a single substantially constructed wheel with internal protected buckets. These internal buckets are milled out of the solid metal, the blades between them, therefore, being integral with the wheel. In this type of turbine the blade does not receive the power-producing action of the steam, but merely serves as a guiding vane or partition between the buckets, the power-producing action taking effect on the curved surface of the disk at the back of the bucket.

A certain amount of wear, of course, does take place on this curved surface, but owing to the easy curvature of the steam resulting from the great width of the bucket, the wear occurring at any portion is very slight.

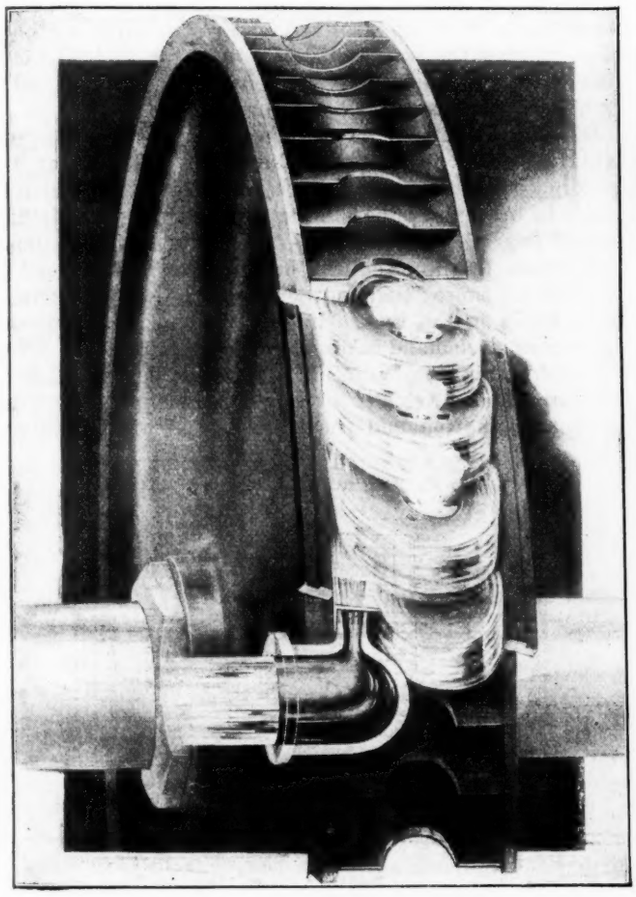


Fig. 7—Steam travels spirally

This cannot appreciably alter the efficiency of the machine, as the entrance and exit angles of the steam have not been altered, but merely the depth of the bucket. The front edge of the dividing blade which comes directly in front of the nozzle is, of course, subject to wear, but it is not detrimental to the turbine efficiency until the blade has become so blunt as to offer an appreciable obstruction to the flow of steam. This edge may be resharpened and the original efficiency restored. It is seldom necessary to replace a Terry wheel until this blade edge has worn back nearly one-quarter of an inch.

It is obvious from the construction of the wheel that reblading is impossible, it being necessary to replace the entire wheel. In spite of the fact that this type of wheel is more costly than the radial bucket type, this feature is not a detriment, for three reasons: First, this will outlast several of the other type; second, the Terry type retains its original efficiency practically throughout its entire life, while the efficiency of the Curtis type starts to depreciate the moment it begins to wear; third, with the Terry type several shutdowns for reblading can be avoided with their attendant expense of labor and loss of service. Thus, although the Terry wheel is more expensive and cannot be rebladed, it proves to be a more economical investment.

The second type of wheel manufactured by the Terry Steam Turbine Co., of the Curtis type, is composed of two or more disks mounted on a single hub so constructed that the first disk may be easily renewed. The

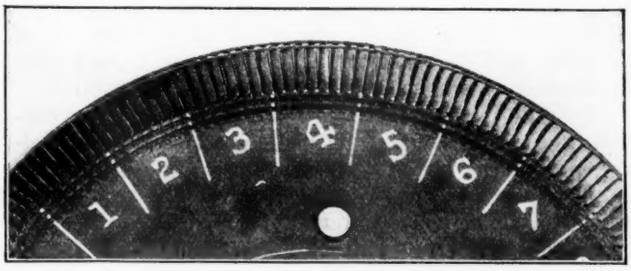


Fig. 8—Monel blades eroded least

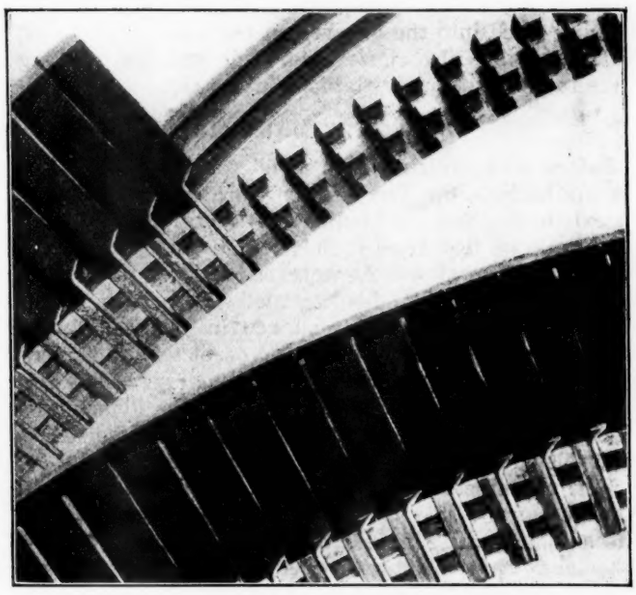


Fig. 9—Blade shanks swedged into side grooves

buckets on the first are made of Monel metal, which is first extruded, then rolled to finished shape, the rolling process resulting in smooth, hardened surfaces, the accuracy being checked against hardened contour gages.

Patented blade fastening secures the blade in slots in the wheel. The blading stock goes through several punch-press operations, shown in Fig 6, as follows: First, roughly cut off, allowing sufficient material for accurate trim; second, flattened somewhat at the end which is to be inserted in the disk. This flattening process first requires that the ends of the stock be annealed, the purpose of the process being to give a definite shape to a great variety of different blade sections. The cross-sectional shape through the flattened end resembles the end of a single-gabled barn with a very low roof. Next, this flattened end is trimmed to

final dimensions so that its width is identical with the wheel disk and its length suitable to the depth of the slot. And last, the outside end to which the shrouding is attached is cut so that a square-shaped post remains for riveting on the shrouding. The blade is then ready for assembly.

The wheel disk is machined to receive the wheel blading as follows: First, two grooves are turned in each side of the wheel near the rim, Fig. 9; second, slots with parallel sides are milled in the edge to the necessary depth. For mounting the blades on the wheel a packing piece made of Norway iron is placed next to the blade as it is inserted in the slot. This packing piece, shown at the bottom of Fig. 6, is so shaped as to straddle the roof-like surface of the blade end; thus the blade end with its packing piece completely fills the rectangular milled slot in the wheel disk. The fit of the blade and its packing piece in the slot is such that the blade may be gently tapped in to the full depth.

After the blades have been inserted, a shrouding consisting of a steel band (punched to receive the protruding ends of the blade) is placed around the blades and is riveted in position by peening over the protruding blade ends. The riveting process is done by a rivet spinner in order that the blading may not be damaged or bent from the force of a hammer blow. To complete the fastening, a swedging process is used which consists of squeezing the exposed portion of the blading and its packing piece into the grooves on the sides of the disk. This squeezing also causes the blade end and packing piece to swell to a very tight fit in the slot.

Testing the Materials

Before standardizing on a metal for the first row of moving buckets, the Terry Steam Turbine Co. conducted an exhaustive test on blading material. This was an actual service test applied to machines in operation in the field. Several wheels were constructed with thirteen different kinds of blading material in each wheel. To insure that the wheel remained in balance, it was necessary to install a like number of blades of similar material on opposite sides of the periphery. Thus for each section of blade material shown in the illustration there is an identical section on the opposite side. The materials chosen for these tests include the best used by turbine manufacturers in the United States and several foreign manufacturers. The number and scope of the wheels used was sufficient to try out each different material under a variety of boiler feed-water conditions. These tests led to the conclusion that Monel metal was better suited to this class of service than any of the metals offered up to the present. The section marked 7 in Fig. 8 is Monel metal. Tests, however, are still being conducted in order that no superior blading material which might become available will be overlooked.

While it is possible to reblade this type of wheel in the field, it is preferable to procure a spare wheel disk that has been bladed at the factory. As the first disk is bolted to the hub, it can easily be removed without taking the hub from the shaft. Thus the time required for replacing worn blading is reduced to a minimum. The disk with the worn blading can be returned to the factory, where automatic machines can easily remove the worn blades without damaging it. It then goes through the same processes of reblading as new disks.

The third type of wheel manufactured by the Terry Steam Turbine Co. is the single-row Rateau type. The blade fastening is identical with the multiple-row Curtis type up to a certain length of blade. Beyond this length Monel metal is used with a thicker section at the root to secure the additional necessary strength. This type of wheel, owing to the low relative velocity of the steam impinging on it, will several times outlast the first row of the action wheel. Thus the importance of reblading becomes insignificant.

Drinking-Water Systems

By H. J. Macintire*

When one recollects the old water bucket, sometimes kept cool with ice, the time lost and the inconvenience of the unsanitary method, the popularity of the modern system is not surprising. Some factories have gone to the extreme of using an ultra-violet ray or other method of sterilizing the water, to make it as sanitary as possible. In first-class offices and hotels the use of cold drinking water on tap is becoming common.

Of all applications of refrigeration the cooling of drinking water is about the simplest. The water is usually cooled to 45 deg. F. by means of a Baudalot cooler to prevent the possibility of danger to the piping should any of the water be frozen during operation. The piping in the circuit is designed to be filled with water at all times; that is, there must be water flowing at all times in the return line to the tank, even when the maximum demand takes place at the fountains. The reason for this is to maintain a plentiful flow at all the fountains and a velocity of flow in the pipe that will prevent stagnation and the warming up of the water

RADIATION LOSS, B.T.U. PER LINEAR FOOT OF PIPE PER HOUR PER DEG. F., DIFFERENCE OF TEMPERATURE

Size of Pipe, Diam., In.	Union Lith	Hair Felt (Two Layers)	Corkboard
¼	0.157	0.086	0.160
½	0.170	0.095	0.167
1	0.180	0.107	0.178
1¼	0.213	0.124	0.199
1½	0.217	0.132	0.220
2	0.269	0.149	0.245
2½	0.272	0.167	0.291
3	0.294	0.192	0.304
3½	0.355	0.211	0.330
4	0.367	0.228	0.345
4½	0.376	0.247	0.385
5	0.446	0.268	0.410
6	0.558	0.307	0.437

from heat absorption. In other words, the flow of water through the circuit back to the water cooler and the pump should be great enough to absorb all the heat leakage and the heat equivalent of the work done by the circulating pump without a rise of more than 5 deg. F. To reduce the pumping work, the circuits are limited usually to 2,000 ft., although systems of 5,000 ft. have been used successfully. Remembering that each horsepower of pump work requires one-fifth ton of refrigeration to offset it, water velocities in the pipes should be limited to 200 ft. per min. as a maximum. Full weight 1-in. pipe is used as a rule.

The amount of water used and wasted is variable, depending upon the temperature and the working conditions of those drinking the water. Hotels and office buildings having an outlet in each room should be designed on the basis of one gallon per person per day. This amount is liberal but it is safe. Stores and office buildings providing outlets in isolated places in the aisles and corridors may have these in use continuously and should be figured on the basis of one-half pint per minute per fountain. In factories it is customary to

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use one-half gallon per person per hour, and in offices to use one-quarter gallon per person per hour. These values are liberal, but if the plant is not designed large enough the entire system fails, and if it is too large it means only a little more in the first cost, as usually the pump can be so operated as to adjust itself to the required conditions.

The number of fountains is also a variable, depending upon the kind of installation. The attempt is made to

In the accompanying diagrams typical illustrations are given of the piping layout in factories, with the risers and fountains. The point here is that there must be a steady flow of water continually past each fountain, that the circuit must not be too long and that there must not be any stagnant portion in it, except for that part from the spring valve at the fountain to the water pipe. If no water is drawn from the fountains, it will all return to the storage and the cooling tank, to be

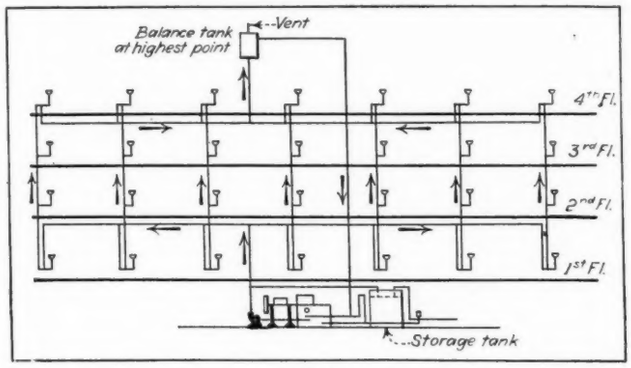


FIG. 1

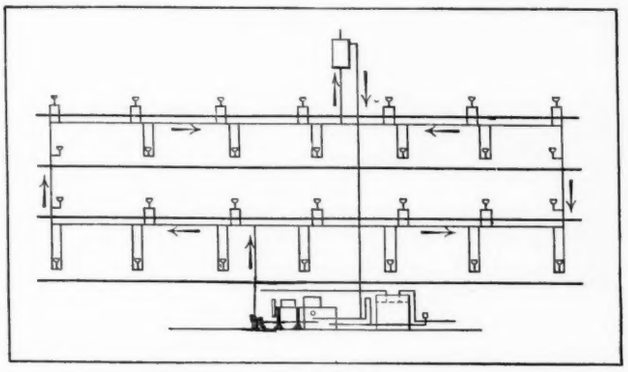


FIG. 2

Figs. 1 and 2—Diagrammatic piping layouts of refrigerated water system

Fig. 1—Using a storage tank. Fig. 2—Simple mill installation.

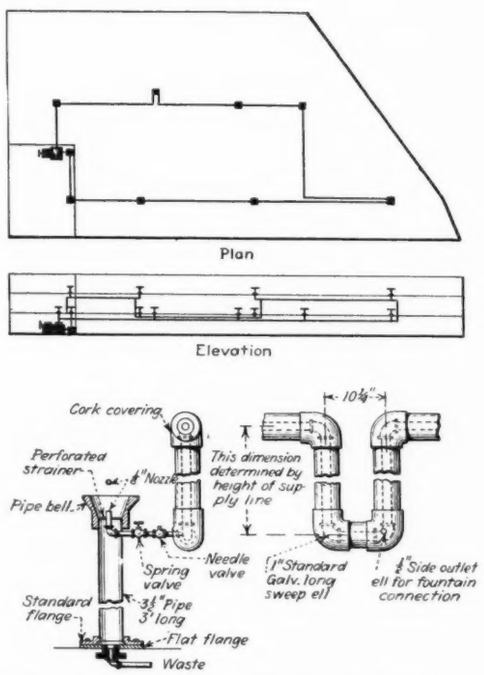


Fig. 3—Fountain made up of fittings

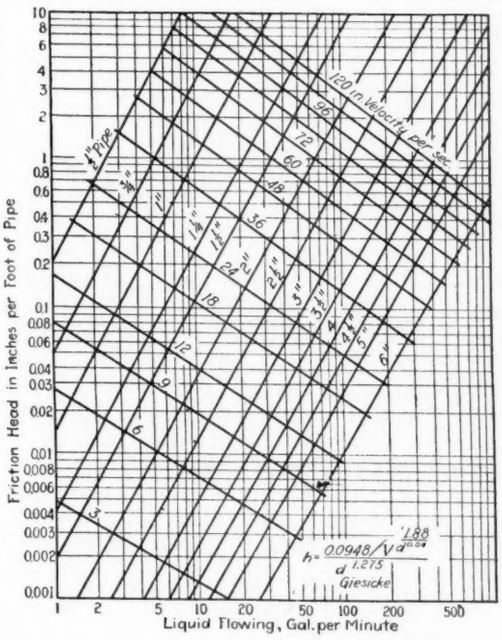


Fig. 4—Friction head and velocity chart

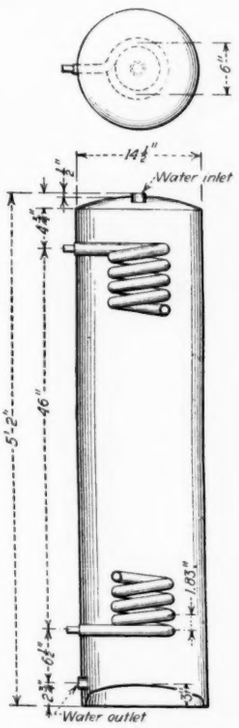


Fig. 5—Water cooler

occasion as little inconvenience as possible for each workman and to work on the assumption that the first cost of the extra fountains is preferable to the cost of the lost time of the workman in walking to a distant fountain. In consequence good practice will allow one fountain per 50 operators or per 100 operators, depending on the details of the job and the congestion of the shop or the office.

The kind of the insulation used is important from the viewpoint of the heat leakage. A good insulation should be used and it should be kept in good condition. The B.t.u. loss for different kinds of insulation is indicated in the accompanying table.

cooled, an amount depending on the friction heat and the heat leakage. A simple design of fountain made up of fittings, is illustrated, also a design of water cooler that is efficient and convenient for small jobs.

The friction-head chart is convenient and easily used. For example, if 10 gal. per min. is required, the head lost per linear foot of 2-in. pipe would be 0.03 in. of water; of 1½-in. pipe, 0.13 in.; of 1¼-in. pipe, 0.26 in.; of 1-in. pipe. 1 in.; and of ¾-in. pipe, 3.7 in. The total pressure drop in the circuit would be the friction head per foot times the total length of the circuit corrected for the pipe fittings. The corresponding velocities can be read from the same chart.

How Akron Handles Smoke Abatement

By R. C. Demary

For several years the Chamber of Commerce kept before the City of Akron the necessity of an ordinance that would prohibit dense smoke from the many factories and office buildings. In June, 1921, they succeeded in having the City Council pass such an ordinance, but it was not enforced because the council failed to take into consideration the need of a smoke inspector.

Continued agitation, however, caused the appointment of a chief inspector and also a City Smoke Commission, which is composed of five practical engineers who have had years of experience in power-plant work. This commission acts in conjunction with the Smoke Department in an advisory capacity and is subject to call by the chief inspector.

Data were secured from every city in the United States and other countries where efforts were being made to eliminate smoke. A careful study was made of every ordinance and of the manner in which the work was being carried on as well as the results being obtained. The Akron department then adopted a system that has brought about wonderful results considering the short time it has been in operation.

Small Manufacturers Object

After the passing of the ordinance and the appointment of a chief inspector, there was a great deal of opposition from many of the smaller manufacturers and apartment-house owners. The remark was frequently made that the city was trying to drive out all the industries and prevent new ones from coming in. This, however, has proved quite the reverse, as inquiries have been received from several industries that require an atmosphere free from smoke and soot.

Akron is strictly a "soft coal city." Practically the only coal available is that which is mined in the southern and eastern parts of the state, and which is very high in volatile matter, thus being very smoky. The first work of the department was to overcome the antipathy of the manufacturers and show them that the high-volatile coals of this district could be burned without smoke and at a considerable increase in economy over that which they were getting.

A plant that was a bad smoker would be visited and a complete survey of conditions made. This would include conditions of the steam lines, traps, temperature of feed water, draft, flue-gas analysis, temperature of gases, condition of boiler settings, and in fact a complete study of this particular plant. This matter would be gone over carefully, and such recommendations as the department deemed necessary would be made to the owner and engineer. In every case these recommendations have been carried out and a considerable saving in fuel has resulted, and at the same time the smoke has been eliminated. In several cases a saving of four and five tons of coal has been made each day and the cost of the necessary changes to bring this about has, in some cases, been as low as fifty dollars.

In one or two cases where the plant owner failed to follow the department recommendations, he was ordered to appear before the chief inspector. The matter was thoroughly gone over and discussed from various angles. The workings of the department were explained, together with the necessity of co-operation on the part of the owners, and the result was that in each instance the owner left with a better understanding and a determination to abate the smoke at his plant and to try to secure better operating conditions.

No furnace of any kind, stack or other apparatus that might affect the efficiency of smoke prevention, is allowed to be installed, constructed or reconstructed, altered or repaired until plans for such work have been submitted to the Department of Smoke Prevention and approved by the chief inspector, who isues a permit for the prosecution of such work. After completion of the work it is gone over with care and, if satisfactory, the permit is stamped approved by the chief inspector.

Permits are not required for private residences or apartment houses if occupied by less than five families.

Where the chief inspector refuses to issue a permit, the applicant may take the matter before the City Commission, and if satisfactory to them a permit will be issued, but in such a case the Smoke Department is relieved from further obligation.

Records Are Kept on File

A complete record of the equipment of each plant as well as a record of the stack observations is on file at the office of the department. This system is very simple, as will be seen from the cards, yet contains all the necessary data for the work of the department.

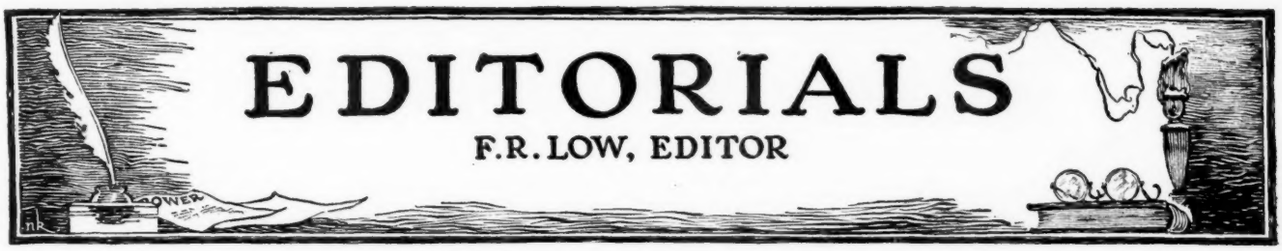
In order that a check may be had on the work being accomplished, a systematic determination of the amount of soot falling in the city is obtained. The city is divided into twelve districts. At a point in each district, advantageously located, a soot collector is located. These collectors are nothing more than hard-rubber jars 4x5 in. and about 6 in. deep, and are placed on the top of some building as near the center of each district as possible. About one inch of water is placed in the jars for the pupose of holding the soot. Rain and dew are sufficient to maintain an almost constant water level. These jars are collected each month and taken to the Municipal Engineering University, where the contents are filtered and the soot and ash contents of each jar determined. An analysis is also made, and for the year 1923 this shows approximately 51 per cent carbon and 49 per cent ash, while the soot fall for the city is about 60 tons per month per square mile.

Chief Inspector Is Well Qualified

The chief inspector is a technically trained combustion engineer with twenty years' experience in practical power-plant operation and has designed and erected some of the best known plants in the country. He is in a sense a consulting and advisory engineer for the benefit of the small plant owner.

Plants that are operating smokelessly are visited and a complete survey and report of conditions made. The report covers every detail, showing just where the losses are and what each loss means in dollars and cents. It might be bad boiler settings, leaking traps, insufficient draft, or any other condition that might tend to lower the efficiency. This report, which is very complete, is mailed to the owner or engineer in charge and also covers recommendations for the betterment of the existing conditions.

If the owner so desires, a complete power-plant test will be conducted with the assistance of the Municipal Engineering University. This test will cover a period of 24 hours.



Is Heat Balance a Mania?

A PROMINENT engineer recently stated that the study of heat balance seems to have become a mania on both sides of the Atlantic. So fascinating has the theoretical study of every means to save heat units in the power plant become, that practical cost factors in some cases seem to have been overlooked, complication has become the rule in power-plant designs and reliability a secondary consideration. Even the sessions of the technical societies have been monopolized by heat-balance discussions. Such thoughts as these prompt an engineer to inquire as to the real effect of these studies in heat conservation.

One cannot deny that the subject of heat balance has proved a most absorbing study during the last few years. It has been taken up by engineers with an enthusiasm seldom noted in pure theoretical calculations. Sober thought has been given to the subject by leading engineers and one cannot believe that these men would overlook the considerations of reliability and simplicity consistent with the results desired.

Consider further the lines along which progress has been made and note the achievements. The earliest studies of heat balance concerned stations with steam-driven auxiliaries. Here an effort was made to balance these in such a manner that all auxiliary exhaust steam was either used to heat feed water or was admitted to the lower stages of the main turbines to do useful work. Some excellent results have been obtained in stations designed along these lines.

Since small steam-driven auxiliaries thus applied are comparatively inefficient, it next seemed possible to effect a saving of fuel by installing a more efficient house turbine to provide current to motor-driven auxiliaries. The exhaust of this house turbine was used to heat the feed water. This resulted in improved operation and freed the plant of long runs of small high-pressure steam and exhaust piping. There may be differences of opinion concerning the reliability of this system, but experience indicates that none was sacrificed.

Attention was next directed to the regenerative cycle and the possibilities of further savings by bleeding the main turbine to heat feed water. As the house-turbine exhaust was not needed to heat feed water, this unit was replaced by current from the main generator or by a second auxiliary generator driven from the main turbine. Bleeder heaters can be built safe and reliable and, aside from additional piping, add no complications to the system. Large thermal gains are possible by the use of such bleeders. However, bleeder heaters cannot be considered wholly by themselves. They must be studied in relation to the boiler, to economizers and to air preheaters. Such studies involve the economies of the plant as a whole and are the ones that are now receiving the closest attention of engineers. So far no general solution has been offered, and it is becoming apparent that each plant must be studied by itself.

Recent installations, while radically different in many respects from the plants of ten years ago, do not seem to be any less reliable in operation, while distinct gains have been made in station performance based on the total cost of output. One of the largest factors in this cost is the fuel per kilowatt-hour. Real progress has been made when heat-balance studies indicate a pound of coal per kilowatt-hour. Heat-balance studies are absorbing the attention of our engineers, but real achievements as indicated by the figures given, justify such developments.

The Heat Meter

WITHOUT meters of various sorts scientific and industrial progress would be slow and uncertain. It is impossible to overestimate the scientific importance of the thermometer, for example, which is nothing but a temperature meter. The ammeter, voltmeter and wattmeter are part of the very foundation of electrical progress. Flow meters using orifices, pitot tubes, weirs and venturi tubes have been of great value in the study of hydraulic apparatus and also in the economical operation of steam power plants.

So far we have had no practical meter for measuring directly the flow of heat. As a result we find in every branch of engineering that those sections (and they are many and important) dealing with heat transfer and heat losses are in a state of scientific confusion. Heating and ventilating engineers still disagree as to the actual heat losses through various types of building walls. The actual and comparative losses through different kinds of heat insulation are the subject of constant disagreement in the power-plant field. The same applies to the loss through furnace walls of various construction. Many other examples of lack of definite knowledge along this line could be produced.

What is needed, evidently, is a heat meter, or rather heat-flow meter, which will measure directly the actual flow of heat. Such a meter has recently been developed by P. Nicholls, Research Head at the A.S.H.V.E. Laboratory in Pittsburgh. This meter, as explained on page 229 of the February 5 issue, consists essentially of a thin sheet of heat-insulating material, the sides of which are covered with a large number of thermocouple junctions so connected that a given average temperature difference between the two sides of the sheet produces a definite voltage difference in two leads to a potentiometer. The average potential difference depends only on the flow of heat through the plate, so that a given potentiometer reading corresponds to a given flow of heat. By using a highly accurate device specially developed to calibrate the heat meter, a curve can be prepared from which the potentiometer readings can be

translated into heat flow with an error less than one per cent under laboratory conditions and two per cent under ordinary field conditions.

We therefore have at the present time an accurate instrument for the measurement of heat flow directly. It is to be expected that this instrument will find a large field of employment in the actual measurement of the losses through the walls of buildings, furnace walls, heat insulation, etc. The possible uses may be divided into two classes, both of great importance. In one class the meter will be used for the development of new knowledge along the lines of heat transmission and heat transfer. In the other it will settle disputes and answer questions that may arise in connection with the actual performance of commercial materials and types of construction.

As at present constructed, the heat meter requires the use of a sensitive galvanometer type of instrument in connection with a potentiometer. The voltages produced are too small for use with a direct-reading or recording instrument. In measuring the flow of heat through thick walls under variable conditions such as are found in heating and ventilating work, automatic records would be of great value, as it is often desirable to obtain continuous readings over periods ranging up to several days in length. If some method can be devised of accomplishing this with reasonable accuracy and at a reasonable cost, the practical usefulness of this meter will be greatly increased. However, even in its present stage of a semi-laboratory experiment, the heat meter holds great possibilities of practical usefulness.

Selling Out to the Central Station

DURING the last few years an increasing number of power-generating stations in industrial plants, hotels, office buildings, etc., have been shut down and the electrical load taken over by central stations. The boilers have been converted to low-pressure heating plants operated only by the firemen. In many cases the managements have found to their surprise that no marked financial saving has been effected by the change, for as a rule the boiler plant operates at lower efficiency. Invariably, it will be found that the operating engineer allowed himself deliberately to sell his plant to the central station.

Many operating men will feel that this is not the case and will jump to the defense of these fellow engineers and claim that they were fine fellows, had long experience in power plants and were licensed as first-class engineers. All these statements are undoubtedly true, but were these men up-to-date engineers? That seems to be the rub. They operated their plants usually according to the standards of twenty years ago. The maintenance of the proper pressure on the steam line and a small amount of coke in the ash were the standards of efficient operation in the boiler room. In the engine room bearings were kept adjusted and engines were occasionally indicated for valve setting. Few data on costs per kilowatt-hour were available, and no attempt made to segregate heating costs. No wonder the central station made an easy contract!

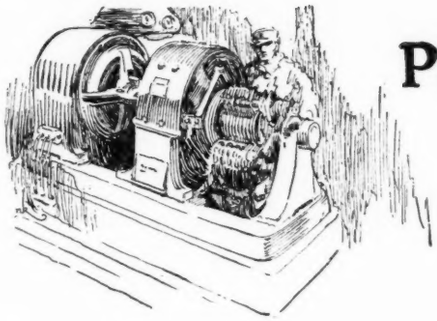
In many of these cases there would be no economic justification for central-station service if the plant engineer kept up to date. The isolated-plant engineer of today must employ the efficiency methods of the central station. He must weigh coal and meter steam to know what he is doing. He must have draft gages to tell his firemen how the dampers are adjusted; pyrometers in the flue gases to indicate excess air and holes in the fires; CO_2 recorders to guide in firing. These last-named instruments are often troublesome to keep in adjustment, and therefore should be the particular pets of the chief. He should have instruments to show what steam is furnished for heating, also others to show power developed. These and other efficiency devices take care and attention so that the chief should know every detail of their construction and how they are adjusted and maintained. He must study all new methods and apply these in his plants. He must train his firemen to get the very best results with these devices. Furthermore, he must study cost accounting so that he can segregate costs and charge up every output with its fair share of costs, and finally these costs must be kept up to date and available for reference at all times.

The isolated-plant engineer who has not done these things exposes himself to the competition of the central station; therefore it should be the business of every such engineer to forget his self-satisfaction and begin studying the problems of how to get out of his rut. It means lots of hard work, much study and some disappointments. These extra efforts, however, are more than compensated by the feeling that he has a steady job, has accomplished real advances and has so improved himself and his plant that he is now regarded as a leading man in his chosen calling.

Limitations of Operating Rules

TYPEWRITTEN, printed or photographic copies of operating instructions in compact form for pocket service are coming into general use in an attempt to systematize the work of power production. Many of these specify minutely what steps to take in starting, operating and shutting down equipment, in recording the history of plant and outside apparatus, and in fixing the responsibility of operating men and engineers for all phases of service continuity. These fill a certain important place in the operating procedure and deserve study, but have their limitations.

The German General Staff files before the war carried the idea of putting facts and plans on paper pretty nearly to the ultimate detail; but the war was lost. Lack of initiative on the part of subordinates resulted from excessive organization and a too rigid discipline; and when the late enemy came up against the red-tape cutting proclivities of the A.E.F., the former's uncertainty as to our movements became a powerful factor in demoralizing the personnel. Similarly, in power-plant operation, paper plans of action are helpful, but these cannot take the place of alert, prompt and sound judgment based on both study and experience. Facing an emergency in a plant representing modern service with all its complexities, with far-reaching results from actions in critical minutes, the operator with the ability to size up a situation and apply cool, intelligent judgment in its handling, is the valuable man. He cannot stop to turn to indexed rules of procedure and he cannot necessarily follow an exact routine in preventing the spread of trouble or in restoring normal conditions. Rules of fundamental instructive scope are most useful in their place; but unless something is left to experience and judgment, the operation of a plant is bound to suffer in critical periods.

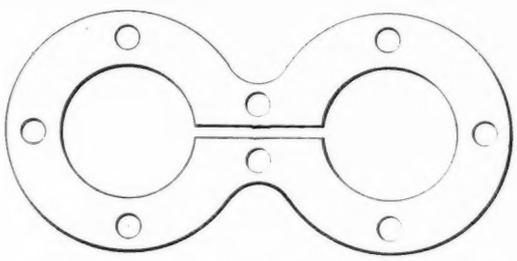


Practical Ideas *from* Practical Men

An Unusual Cause of Pump Trouble

Some time ago my employer sent me to locate the trouble on a duplex pump that was not operating properly. The pump would work slowly, then give a few jerky strokes, finally stop for a short interval, and then repeat the operation.

After examining the steam valves and the water end of the pump without finding any cause for the trouble, I removed the steam cylinder head and discovered a blowout in the lead gasket, as shown in the illustration. Judging from its appearance the cut was an old one



Steam passage through cylinder-head gasket

and had been made with a sharp knife, leaving only a small section at the center which had finally blown out, allowing sufficient steam to pass from one cylinder to the other to cause the trouble mentioned.

Toronto, Ont., Canada. J. E. NOBLE.

Using the Welding Outfit in Renewing Babbitt Bearings

A method that we use in our shop for renewing babbitt bearing linings where it is necessary to have a close fitting bearing, has, in our opinion, many advantages over the old method of doing this work.

Take, for example, a motor bearing that, through wear, is in danger of letting the rotor come in contact with the field coils. The usual procedure has been to have the bearing removed, melt out the babbitted surface, prepare a wooden or metal mandrel (smaller in diameter than the bearing desired), place it centrally with respect to the bearing, seal up the holes and crevices, then pour the babbitt. The next task, as soon as the bearing has cooled down, is to remove the superfluous metal, place the bearing in the lathe and turn it to size, cut the oil ring grooves and finally drill out the oil holes, and the job is finished.

The method we use now when a bearing lining comes into the shop for renewal, is to take our welding outfit with a No. 4 tip on the torch and, with babbitt prepared in $\frac{3}{8}$- or $\frac{1}{2}$-in. rods, build up the surface to the required height. A complete bearing for a 125- to 300-hp. motor can be built up in from 30 to 45 minutes by this method. Oil holes and oil-ring grooves are not filled up in the operation; in fact, the entire job can be completed with the torch in the time it formerly took to remove the old babbitt, and it has a still further advantage, in that the time of machining operation is cut in half. All danger of overheating the babbitt metal or warping or twisting the cast shell through overheating is overcome, and the finished job is superior in every way to one renewed by the old method.

Kemmerer, Wyo. THOMAS HALL.

The Conservation of Coal for Power Purposes

The proper use of coal has been the topic of many papers and discussions, with the result that the superpower plant is now put forward as affording the solution to the whole problem.

It is not my intention to offer any objection to the scheme, for the superpower plant should work out some saving of fuel for the large commercial power companies. But the amount of fuel saved by placing power plants near the coal mines is not so great as might at first appear, because there is a line loss of from 10 to 15 per cent, and an additional transformer loss.

The increasing demands for power are beyond what the commercial power plant can cope with and as for reducing the amount of coal used per capita, I doubt the result.

In the district north of Richmond, Va., a manufacturing plant requiring around 100 to possibly 150 hp. can be supplied with power by the commercial power companies at a cost advantageous to the consumer. In this locality, however, as all the manufacturing plants require steam for heating for six or seven months in the year and many use steam in the manufacture of their products, the cost of buying power over 100 or 150 hp. would be greater than of generating it at their own plants. Only a small amount of the heat is extracted from steam used for power purposes; good steam plants have a thermal efficiency of from 7 to 10 per cent and commercial power plants 18 per cent. Therefore if a manufacturing plant requires all the exhaust steam for process work, its cost for fuel for power will be only 10 per cent additional. This power cannot be produced by a commercial power plant for the same amount of coal.

Such industrial plants as sugar refineries, dye and finishing plants use more steam than the amount given off by the power-generating machinery; also a large number of plants such as steel mills and glass plants, utilize waste heat for generating all the power they use.

The United States is accredited with using 0.33 hp.

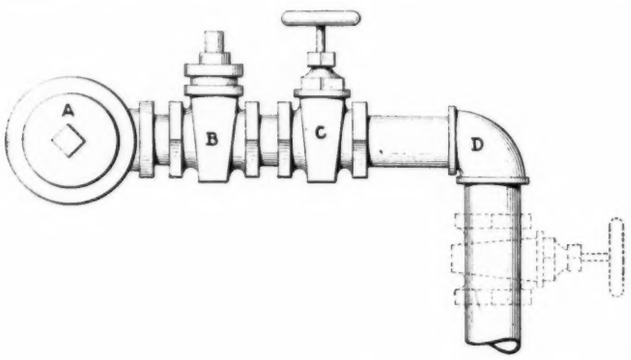
per capita, with a possibility of 0.50 hp. in the next five years. If this is correct, the commercial power plants will be unable to carry their share of the load.

The greatest saving in coal could be effected by improving industrial power plants, and the greatest improvement could be made in the boiler rooms. The average boiler-room efficiency of industrial plants is probably about 50 per cent; but in many plants this could be raised to 70 or 75 per cent, at a cost attractive to the owners. Since industrial power plants are said to use 25 per cent of all the coal mined, this saving would amount to something worth while.

Philadelphia, Pa. WALTER DALTON.

Blowoff Cocks and Valves Give Long Service

The illustration herewith shows the blowoff piping of a boiler that has been in service for nearly thirty years. The main pipe is shown at *A* which is an end view of a 4-in. tee with a 2-in. side outlet. This 4-in. pipe extends through the brick wall and the combustion chamber and is screwed into a saddle that is riveted



Arrangement of blowdown valves and connections

to the shell of a horizontal return-tubular boiler. When this boiler was installed, it was assumed that this pipe would never need to be covered to protect it from the heat, and this long term of service without failure has proved this assumption to be correct.

An asbestos-packed plug cock is shown at *B*. It is a part of the original installation and is still in good order. The gate valve *C* was installed about fifteen years ago and is still tight. When blowing down the boiler, the following schedule is followed: The gate valve *C* is opened wide, then the cock *B* is opened slowly until it is full open. When enough water is blown out, the cock *B* is slowly closed, after which the gate valve is closed tight. By following this method the friction due to the escaping water under high pressure is confined to the cock *B*, and if it should leak, it is of no special importance because the gate valve prevents the escape of the water.

The gate valve *C* is located with its stem in a vertical position, which is not the best that could be devised, as it would seem to provide a pocket for the collection of scale, but it has not proved so in practice. The reason for its present location is due to the fact that there was not room enough for it between the fittings below the elbow.

A similar arrangement of blowoff valves and connection has been in use for fifteen years on another boiler in our plant, the only difference being the location of the gate valve. In this case the valve is placed in a horizontal position as shown by the dotted lines. This position is preferable, as scale cannot collect in the pocket under the gate.

A precaution that should always be taken with regard to blowoff valves and connections is to provide a means of easy or quick exit from the rear of the boiler in the event of piping failure while blowing down the boiler.

Utica, N. Y. W. H. WAKEMAN.

Experience in Controlling Spontaneous Combustion in Stored Coal

Last summer it was decided to stock about 1,500 tons of soft coal, this being approximately the amount needed to carry our heating load during the winter. This coal was received in lots of about 300 tons a month and was unloaded by means of a small clamshell bucket crane mounted on an automobile truck chassis. It was stored on a plot of land approximately 3,000 sq.ft. in area, thus giving an average depth of around 13 ft. Some portions of the pile were considerably deeper than this. The carry-over from the previous season was 220 tons, and about 1,300 tons of fresh coal was stored in addition to the regular stock.

This coal came from the Clearfield district of Pennsylvania and is run-of-mine. It is extremely friable, however, and a large percentage is practically dust. The average proximate analysis follows: Moisture, 1.1 per cent; volatile, 25.2 per cent; fixed carbon, 64.4 per cent; ash, 9.3 per cent; sulphur (separate determination) 3.6 per cent; B.t.u. per lb., 13,900.

Owing to the character of the coal, spontaneous combustion was anticipated, but no artificial vents were provided. We did, however, insert into the pile at about 10-ft. intervals, pieces of ½-in. pipe, pushing them down to the bottom, into which we placed odd pieces of ¾-in. diameter steel rods. A daily inspection was made by withdrawing the rods and feeling them to determine any increase in temperature. Quite unexpected conditions were observed. Some parts of the pile failed to show any rise in temperature, while other parts showed a rapid rise, this being particularly observed in one section of the pile within ten days after being unloaded. Another unlooked-for development was the closeness to the surface of the heating zone—in some cases extreme heat was noted within one foot of the surface, while rarely did the heated area extend to a depth of more than four feet. As stated previously, daily observations were made by feeling of the small rods within the pipes, and when heat was noticed, a small stream of water was caused to filter through the coal pile by pushing a pipe lance connected to a water hose into the affected area. In some cases, we opened a small trench across the heated zone, into which water was run and allowed to settle into the pile. As soon as the temperature fell, the water was discontinued.

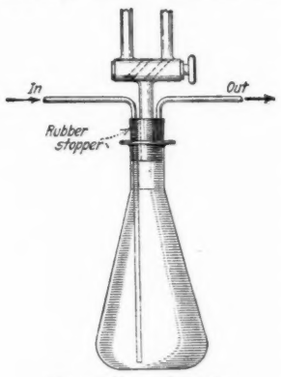
The daily observations were made by an employee in connection with other duties, so no record was kept of his time, neither did we attempt to meter the water used. The water consumption was so slight, however, as not to show appreciably on our monthly consumption. Up to the present time there have been no indications of burning, although about 60 per cent of the entire storage has been used. J. W. RUPERT.

Newark, N. J.

Comments from Readers

Testing for Dissolved Oxygen

The four-page article in the Dec. 11, 1923, issue, entitled "Field Method for Determining Dissolved Oxygen," was particularly interesting to the writer owing to the fact that he has had occasion to assist in making extensive investigations on the same subject. Considering the results of these investigations, it seems appropriate to discuss them in connection with some of the methods of sampling and testing water for dissolved oxygen as outlined in the article to which reference has just been made.



Sampling Bottle

The method under discussion is based on the standard Winkler method, which is generally conceded to be the most accurate and at the same time the most simple and convenient method available for the purpose. There is no question, therefore, of the value of the Winkler method, but the modifications and particularly the mode of sampling varies to some extent and the writer wishes to discuss the modifications suggested in the article with especial emphasis on the method of sampling.

The method of sampling is, without doubt, the most important part of the test owing to the fact that water that has been partly or completely deaërated has a noticeable tendency to redissolve air if it is given the slightest contact with the atmosphere. The article mentioned suggests collecting the sample under a floating oil to prevent contact with the atmosphere. On first consideration it would seem that this procedure would simplify the test and furnish an efficient method of preventing pollution by the atmosphere. This is partly true, but unfortunately the chemical features of the test are such that the oil is certain to introduce an error. The Winkler test, as is more or less generally known, is based on chemical reactions which liberate free iodine in exact proportion to the amount of dissolved oxygen originally contained in the sample, and the iodine is then measured by titrating with a standard solution of sodium thiosulphate. Now, if the sample is under oil, the iodine, when liberated, is in direct contact with it and the question arises as to whether iodine will be absorbed by the oil.

The apparent advantages of using oil were recognized by the research department in the organization of which the writer is a member, and an extensive investigation was made to determine what particular oil would be most suitable for the purpose. The investigation was carried out along theoretical and experimental lines through all varieties of mineral, vegetable and animal oils, and it was definitely proved that none of these was suitable for the purpose owing to the fact that their chemical behavior is such that they all absorb small amounts of iodine. This iodine is taken into chemical combinations by replacing hydrogen in the hydrocarbons of which the oils are principally composed. Different oils vary in their capacity for absorbing iodine, but there is none that will not absorb it to some extent. The light transformer oil mentioned in the article referred to would probably absorb as little iodine as any oil available, but the amount is sufficient to interfere seriously with the accuracy of the test, especially in testing water with low oxygen content, where the greatest accuracy is usually desired. If an attempt is made to saturate the oil with iodine, an error is introduced in the opposite direction in that iodine passes from the oil to the sample, causing higher results. It might be supposed that a fresh portion of oil could be used for each test and a correction made. However, this was shown to be inaccurate owing to the fact that samples containing different amounts of dissolved oxygen and hence liberating during the test different amounts of iodine, would transfer different amounts of iodine through the oil layer, making a blank test of little value. Changes in temperature and the time the sample is allowed to stand before the test is completed would also tend to make a blank test worthless.

Having exhausted the possibilities of using an oil layer, the investigation was extended with the idea of finding some individual organic compound such as toluene, benzene or any one of numerous others which would be suitable for the purpose. The compound would necessarily have to be a floating liquid that would not absorb iodine, and after extensive study and experimental work it was definitely proved that there was no compound suitable for the purpose. All the floating liquids, such as benzene and toluene, absorb small amounts of iodine either by combination or displacement, and derivatives of these and other compounds which are saturated with respect to iodine have too high a density to float on water.

The idea of using a floating liquid was then abandoned and the method described in the April 25, 1922, issue under the title "Portable Test Kit Measures the Corrosiveness of Water," was used. The writer has made extensive use of this method and can vouch for its accuracy and simplicity. It may be recalled that the method of collecting samples in the latter procedure consists of running the water through a glass tube leading to the bottom of a 500-c.c. flask and allowing the water to run until the flask has filled completely and the water has washed through for a few minutes. The flask is kept closed with a three-hole rubber stopper. When the sample is ready, the water flow is shut off and the reagents are added through the third hole in the stopper. If extreme accuracy is desired, the possibility of introducing air with the reagents may be avoided by inserting in the third hole a two-way stopcock and using it for the admission of the reagents. Such an arrangement is shown in the accompanying sketch. A two-way stopcock is used because some of the re-

agents are incompatible in concentrated form and must be introduced through separate tubes. This method of collecting samples is more accurate and more convenient than using a floating oil.

A few other points in the article suggesting the use of floating oil are worthy of comment. For instance, cooling the sample through a glass coil immersed in cracked ice is undesirable because the colder the sample is the more susceptible it is to pollution from the atmosphere. If the temperature of the water is not more than 140 deg. F., no cooling is necessary. At temperatures higher than 140 deg. the sample should be cooled below this temperature. Another criticism of the article is the quantity of reagents used. Its author suggests 8 c.c. manganese chloride and 12 c.c. each of alkaline iodine solution and sulphuric acid. This represents a large excess above the amount required for the test. The solutions should be of such strength that 2 c.c. each will be sufficient. In this case the possibility of introducing dissolved air with the reagents is greatly reduced.

The method used by the writer and described in the April 25, 1922, issue is employed in numerous power plants throughout the country and is giving satisfactory results.

D. H. JACKSON,
Elliott Company.

Jeannette, Pa.

Diagnosing Engine Trouble with the Indicator

I have noticed from time to time in the columns of *Power* contributions on the steam-engine indicator and its application in setting the valves of steam engines as well as locating trouble of various kinds. Just recently, trouble which seems to me quite out of the ordinary developed with a 20x42-in. Corliss engine in the plant where I am employed.

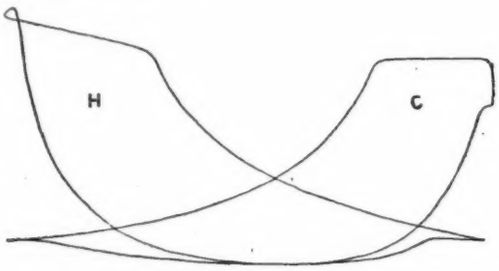


Fig. 1—Twisted valve stems caused high compression

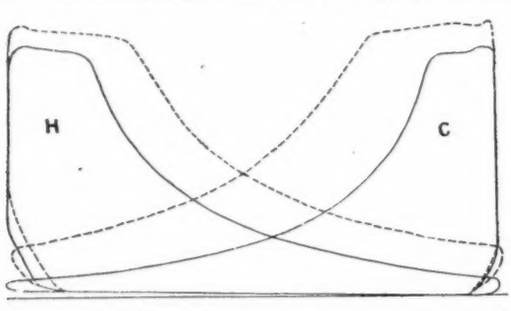


Fig. 2—Full-line diagram shows friction load, dotted line, normal load

On starting up the mill the morning of Jan. 2, the engine ran only a few minutes, then stopped. The operating engineer sent for me and we made a hasty examination. Knowing the exhaust-valve stems were badly worn, we proceeded to examine them. The first bonnet removed, revealed a broken stem, it having twisted off in the stuffing box where it was worn to about two-thirds the original diameter. The broken members were taken to the machine shop where a new stem was forged and finished in a short time. The keyway was located in the new stem by placing the broken pieces of the old stem together, which at that time seemed proper but which later proved to be wrong. However, the new stem was finished and put in place and the engine started up. The engine came up to speed as usual, but when the machines in the mill were put on one after another, it began to slow down perceptibly, till finally the governor went so low that the safety cams came into action and the engine stopped.

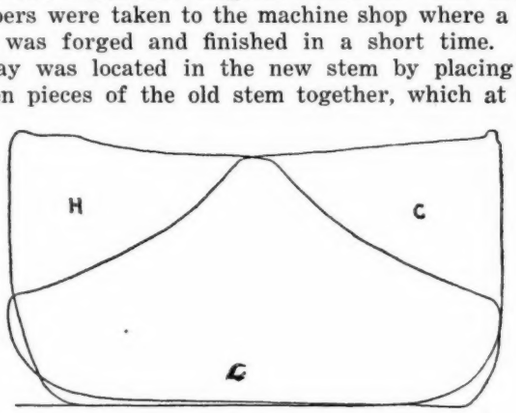


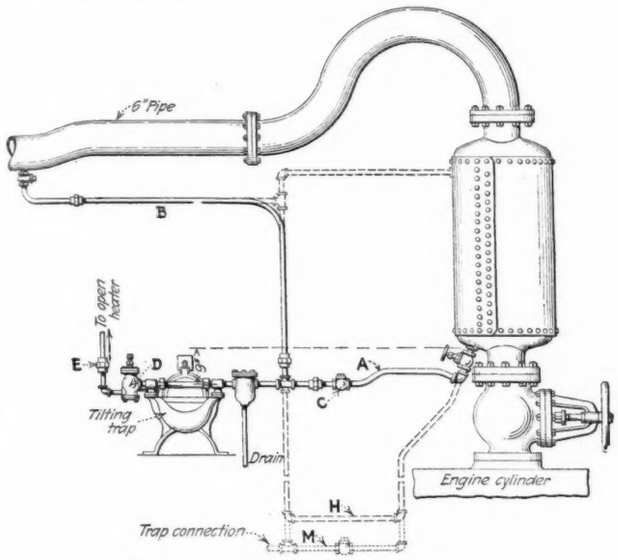
Fig. 3—Diagram showing overload carried

It occurred to us that possibly we had made a mistake in marking the keyway, so we decided to use the indicator to locate the trouble. The indicator was quickly connected and the engine started again. The first diagram obtained, shown in Fig. 1, bore out our assumption that the exhaust-valve stems had become twisted before the one on the head end broke. The effect of the twisted stems is clearly indicated by the early closing of the exhaust valves and consequently high compression, the one on the head end being earlier than the one on the crank end. It is interesting to note the direction in which the valve stems were twisted. It is evident that they were twisted during the release period or during the time that the valve was opening wider, when under more favorable load conditions there should have been very little pressure on them. However, at the time the accident happened there likely was an overload on the engine which resulted in a high terminal pressure—at least this is the conclusion we arrived at. We removed both exhaust valves at once. The new stem was turned bottom-side up in order to get stock for another keyway, and a new stem was made for the other valve. The valves were then replaced and set in the usual way. The wristplate was placed on center and the keyways located on the stems, which were then taken to the machine shop and finished. When the valves were again put in place and the engine started, the diagrams shown in Fig. 2 were obtained. The full-line diagram was taken with the friction load and the dotted-line diagram with normal load on the engine, the latter being obtained with slightly higher steam pressure. Fig. 3 shows the overload that the engine is subjected to a good share of the time. The engine runs 90 r.p.m., and the diagrams were taken with a 60-lb. spring. Of course all this could have been accomplished without the use of the indicator, but for locating trouble quickly the instrument and a knowledge of its use are a great help.

FRANK E. BATEMAN.
Libby, Mont.

Will Changing the Connection to the Trap Improve Its Operation?

I was much interested in the trap problem submitted by Mr. Van Keehern in the Dec. 4, 1923, issue and the comments of A. J. Bell in the Jan. 1, 1924, issue, and I am of the opinion that the trouble is mainly in the piping arrangement. I think that with some modification in the connection to the trap, it would work perfectly.



Changes suggested in connection to trap

Referring to the illustration, placing the check valve *C* in the pipe *A*, as suggested by Mr. Bell, would prevent a blow-back in case the pressure in the separator was lower than that in pipe *B*; otherwise it is a detriment, as the weight of the check must be overcome by raising the water head in the separator.

The pipe *B* should connect with the pipe *A* as close to the trap as possible, also the pipe *A*, instead of rising slightly, should form a loop *H* as shown by the dash line. A still further improvement could be made by connecting the pipe *B* with the top of the separator as shown. This would prevent any unbalance of pressure between the drain *B* and the separator which might tend to affect the flow of condensation to the trap.

Brooklyn, N. Y. C. Q. ENGGREN.

The trap problem submitted by Mr. Van Keehern appears quite simple when a pressure analysis is made.

The pressure in the main at the point where the drain *B* is connected is always as high as it is in the separator, and whenever steam is flowing the pressure is higher by an amount equal to the friction loss through the steam pipe and part of the separator. With this clearly in mind the drain line becomes a small auxiliary steam transmission line carrying steam from the inlet of the drain *B* to the inlet of drain *A*, where it connects and delivers its steam to the separator.

The check valve recommended by Mr. Bell in the Jan. 1 issue would prevent the flow of steam and would permit the drain *B* to operate provided the trap was in good operating condition, but the drain *A* would not operate without sufficient head of water in the separator to overcome the friction in the steam main and lift the check valve.

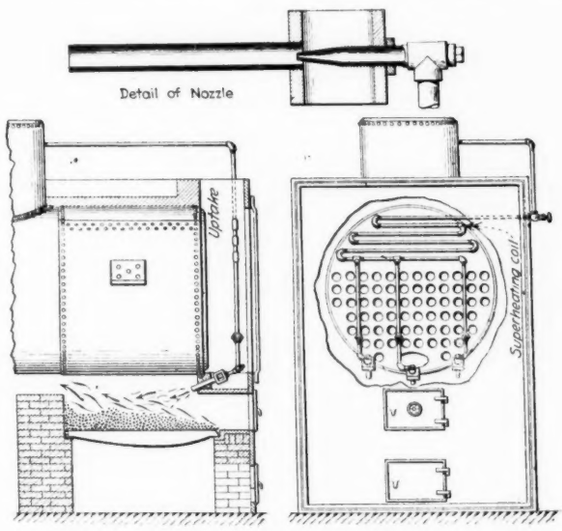
A reciprocating engine service, as shown, might cause small quantities of water to pass through the check, but the result would not be satisfactory. As a rule two points in a steam line at which much difference of pressure may exist should not be connected together in a drain system unless a special type of connection is used, which consists of a drop-leg in combination with a check valve located close to the trap, as shown by the dotted line at *M*, so that the head of water previously mentioned will not extend up to the separator.

Pittsburgh, Pa. W. S. HOBBS.

Eliminate the Smoke

The discussion by Mr. Odell in the Jan. 1 issue entitled "Eliminate the Smoke" brought in several requests for a description of the apparatus to which he refers. This appliance was illustrated and described in the Jan. 10, 1911, issue of *Power* and is reproduced herewith.

Referring to the illustration, three small cast-iron boxes open at two sides are placed in the bottom of the uptake and are connected to the superheating coil, also located in the uptake, in such a way that the jets of heated air and steam can readily be directed at any desired angle, although the best practice seems to be to direct them at an angle to meet the junction of the grate bars with the bridge wall. An enlarged view of the jets is shown at the top of the figure in order that the construction may be more readily understood. The jets are of cast brass about 4 in. long with a ½-in. pipe thread cut on the outside, well down, so that adjustments can be made if desired, and then fixed by means of a locknut. The connection to the steam jet is made with a ½-in. tee, in one end of which is a plug. This is to permit the insertion of a wire for removing any obstruction that might get into the jet. The steam consumed by the device is about 1 per cent of the total steam generated by the boiler.



Arrangement of nozzles and superheating coil

The principle of operation is that some of the flue gas and excess air at high temperature is drawn from the breaching or uptake and directed into the furnace above the fire. This hot blast tends to aid in the combustion of the particles that would otherwise escape up the stack unburned. EDITOR.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Influence of Water Level on Boiler Economy

What difference would there be in the amount of coal required for the generation of steam carrying three gages of water in a boiler compared with one gage? C. H. L.

A greater amount of coal is required for raising the greater amount of cold water up to the temperature of evaporation, but once that temperature is attained, the same amount of coal is required for transfer of the same amount of heat, regardless of the water level. However, when the boiler contains three gages of water, it is more likely to prime; that is, water is more likely to be carried over with the steam discharged, causing delivery of a smaller quantity of dry steam, and the wet steam so delivered could not develop as much power per pound of coal in an engine as steam at the same pressure containing less moisture. But when the same pressure and quality of steam is generated, the result per pound of coal would be the same, whether one gage or three gages of water were carried in the boiler.

Temperature of Steam in Coils of Vacuum Heating System

In a factory vacuum heating system where the steam supply is at 2 to 5 lb. pressure and there is 10 in. vacuum at the vacuum pump, what is the temperature of steam in the pipe coils and radiators? B. L.

The pressure delivered by any steam main branch depends on the diminution of the supply pressure in the main, caused by the drafts of steam through the branch, pipe friction and condensation and drafts of steam through other branches or outlets back to the point of main supply.

In the same way the pressure in a return branch is greater than the pressure in other return branches or parts of the return main nearer the vacuum pump. For practical purposes the average pressure within a coil may be considered to be the mean of the pressure in the supply and return branches connected with the coil. Satisfactory circulation usually can be maintained for 2 lb. per sq.in. difference of pressures in the supply and return connections.

In a vacuum heating system, where 10 in. vacuum, or an absolute pressure of 9.8 lb. per sq.in. is maintained at the vacuum pump, the pressure in the return connections may be anything from 2 lb. below the pressure of the initial supply, to about 10 lb. per sq.in. absolute, according to the size and nearness of the return connection to the vacuum pump. Hence, when the initial supply pressure of the system is 2 lb. gage, or 17 lb. absolute, the average pressure within the coil will be something between $(17 + 10) \div 2 = 13\frac{1}{2}$ lb. absolute, and $17 - 2 = 15$ lb. absolute; or the temperature corresponding with those pressures may be between 207 and 213 deg. F. With steam supplied to the system at 5 lb. gage, or 20 lb. absolute, the average temperature within the coil will be something between $(20 + 10) \div 2 = 15$ lb. absolute and $20 - 2 = 18$ lb. absolute, so that the steam within the coil would be at a temperature between 213 and $222\frac{1}{2}$ deg. F.

When it becomes necessary to operate with higher vacuum for the sake of obtaining satisfactory circulation in only one or two coils of a system, the average temperature of the others becomes lowered and, unless the discharge valves of the active coils are partly closed to prevent unnecessary reduction of pressure, there will be a reduction of their coil pressure and temperature, greater loss of steam condensed in the vacuum pump, and higher capacity required of the vacuum pump.

Increased Compression from Twisted Valve Spindle

In what direction would an exhaust valve of a Corliss engine be moving for the valve spindle to become twisted, causing earlier compression? A. W. C.

Earlier compression would be due to earlier closing of the exhaust valve. When due to twisting of the spindle, it could be the result of moving the valve ahead of the angular motion of the spindle as the valve was moving or ready to be moved in the direction for closing. However, if the twisting occurred while the engine was running it would be due to an obstruction to motion of the valve as would be caused by retarding the valve by excessive pressure holding it to its seat, while a twisting force was exerted through the spindle, tending to move the valve in the direction of its motion when opening. Motion of the valve in the direction of opening occurs during the latter half of the admission stroke and first half of the exhaust stroke, and returning, the valve moves in the direction for closing during the latter half of the exhaust stroke and the first half of the admission stroke.

Draft with Excessive Chimney Capacity

We have a round brick chimney, not in use, that is 125 ft. high, with inside diameter 10 ft. at the base. If we were to connect one 150-hp. boiler to this chimney, would there be sufficient heat to maintain a draft, or would there be an excess of draft? G. R. C.

There would be some draft with any gases discharged into the chimney at higher temperature than the temperature of the atmosphere, since the cooling effect of the atmosphere could not reduce the temperature of chimney gases below that of the atmosphere. On the other hand, there could not be any greater force or pressure per square inch of draft than would be pro-

duced by the same temperature of chimney gases discharged from any number of boilers. However, the smaller the quantity of uptake gases at given temperature discharged into the chimney per hour, the lower their average temperature in the stack and the lower the draft pressure at the base of the stack.

A stack of the dimensions given would have about 5,000 sq.ft. of superficial wall area exposed to the weather. Allowing the cooling effect of the atmosphere to be transmission of heat at the rate of 0.35 B.t.u. per degree difference of temperatures inside and outside, for an atmospheric temperature of 60 deg. F. the loss of heat per hour for a chimney temperature t_c would be

$$5{,}000 \times (t_c - 60) \times 0.35 = 1{,}750t_c - 105{,}000 \text{ B.t.u.}$$

Assuming that there would be 5 lb. of coal burned per boiler horsepower per hour, and 24 lb. of flue gas per pound of coal, the weight of gases delivered would be $150 \times 5 \times 24 = 18{,}000$ lb. per hour; and assuming the temperature of the gases to be 550 deg. F. as discharged from the boiler uptake, and their specific heat to be 0.25 per lb., the heat in the gases as discharged from the boiler would be $18{,}000 \times 550 \times 0.25 = 2{,}475{,}500$ B.t.u. above 0 deg. F.

The heat remaining after deducting the heat lost would be $2{,}475{,}000 - (1{,}750t_c - 105{,}000) = 18{,}000 \times 0.25 \times t_c$; hence $t_c = 412$ deg. F.

The formula for the force or intensity of the draft, allowing that the flue gases have the same density as air of the same temperature is:

$$D = 0.52H \times P \left(\frac{1}{T} - \frac{1}{T_1}\right)$$

in which

D = Draft produced, measured in inches of water;
H = Height of top of stack above boiler grate, in feet;
P = Atmospheric pressure, pounds per sq.in.;
T = Absolute atmospheric temperature;
T_1 = Absolute temperature of stack gases.

Having $H = 125$ ft.; $P = 14.7$ lb. per sq.in.; $T = 60 + 460 = 520$ and $T_1 = 412 + 460 = 872$, by substituting, the formula becomes

$$D = 0.52 \times 125 \times 14.7 \left(\frac{1}{520} - \frac{1}{872}\right) = 0.74 \text{ in.}$$

stack draft, which should be sufficient for burning 20 to 25 lb. of anthracite pea coal per square foot of grate per hour.

Use of Oil and Spring Buffers on Traction Elevators

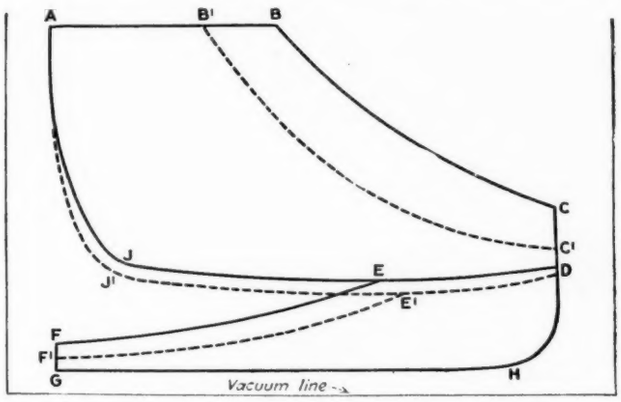
What are the advantages in having oil and spring buffers on traction elevators? W. H.

On traction elevators the advantages in having oil and spring buffers on the counterweights are that the buffers will bring the weights to a gradual although quick stop, should occasion necessitate, and this action, in turn, brings the car to the same quick stop. Without the oil and spring buffer on the counterweights, the car would, upon the sudden landing of the weights, continue to rise until its momentum was overcome, and there would be some inches or feet of slack cable for the car to drop back upon, and this might result disastrously. The landing of either the car or the weights, reduces the friction on the driving and auxiliary sheaves to such an extent that, although the motor may keep revolving, the car or counterweight, as the case may be, would stop because of absence of traction. The landing of either the car or counterweights on any type of buffer, other than the oil and spring combination, is much less desirable than it is on this combination type. For safety reasons, therefore, the combination type should be used and maintained in the best possible manner.

Variation of Receiver Pressure with Variable Cutoff in H.-P. and L.-P. Cylinders

What causes the receiver pressure to vary in a compound engine while the governor controls cutoff on both cylinders? F. K. C.

Referring to the figure, where *ABCDJ* is the high-pressure diagram, and *DEFGH* the low-pressure diagram before change of cutoff, *DE* may be considered the line of receiver pressure from release of exhaust from the h.-p. cylinder up to the point of cutoff in the l.-p. cylinder and *EJ* the line of receiver pressure to the time of closing the h.-p. exhaust valve, followed by compression of exhaust left in the h.-p. cylinder. With change of load and shortening the h.-p. cutoff to *B'*, the h.-p. terminal pressure drops to *C'*, and when release occurs to a receiver of finite volume, the same volume of steam, but of less pressure, is placed in communication with the receiver, and the pressure at *D* is lower than previously. Hence the receiver pressure is lower during the next succeeding period of admission *DE'* from the receiver to the l.-p. cylinder. But, with a shorter cutoff there is less volume as well as less pressure of steam discharged from the receiver to the l.-p. cylinder than with the l.-p. cutoff at *E*, and the next equal h.-p. volume of steam expanded to *C'* results in higher receiver pressure than represented by the dotted line *DE'*.



Variable cutoff in h.-p. and l.-p. cylinders

The product of the pressure and volume of steam admitted to the h.-p. cylinder up to the time of cutoff must be equal to product of pressure and volume of steam received by the l.-p. cylinder. Hence if *B* and *B'* are respectively the same fractions of actual cutoff in the h.-p. cylinder as *E* and *E'* of the l.-p. cylinder, the original receiver pressure will be restored. But the smaller the receiver the greater the temporary drop before recovery of normal receiver pressure.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

The Idea of Heat Balance

THE first thing to know about "heat balance" is that the term has two distinct meanings. In one meaning a heat balance corresponds with a bookkeeper's balance, and is nothing but a record showing the energy entering and leaving the various pieces of apparatus. If a circle is drawn around any piece or group of apparatus in the power plant, it will be found that the amount of energy flowing into the circle is equal to that flowing out.

The "Bookkeeper's" Heat Balance

This must necessarily be true, since energy cannot be created or destroyed. The amount of energy coming out must then equal that going in, unless some is stored up inside the circle. In the long run any slight energy storage capacity is negligible. This condition makes it possible to write a balance for any piece or group of apparatus around which the imaginary circle has been drawn. In the left-hand column will be put all the energy going in, and in the right-hand column all that going out. If the measurements and computations are correct, the two columns will add up to the same total. It is, of course, necessary to use the same unit for all the portions of energy considered. Heat balances of this kind can be prepared for any kind of plant.

Evidently, then, when engineers talk about maintaining a heat balance, they do not mean this kind of balance. This bookkeeper's heat balance maintains itself, whether any attention is paid to it or not.

Heat Balance Has Another Meaning

But the term "heat balance" has come in recent years to have a second meaning, and it is with this that the present article is primarily concerned. In this new sense the term "heat balance" means a *desirable* heat balance and centers mainly around the question of heating the feed water. Now it needs no argument to prove that the most desirable heat balance, other things being equal, is that which enables a given amount of power to be produced with a minimum consumption of fuel. Yet the modern power plant is so complex that this point is often lost sight of and consideration given only to the efficiency of the individual units. As a result many false conclusions are drawn.

A good example may be found in the field of exhaust heating or process work, where a change in the efficiency of the engine used may, under certain conditions, have no effect whatever on the fuel consumption.

Coming back to the typical power plant, where the question of exhaust steam for process or heating is a minor consideration, heat balance comes practically down to the method of heating the feed water. Take the case of a condensing plant with condensate at 90 deg. It is not desirable to send this water to the boiler at this temperature.

Up to a few years ago this meant heating the feed water from the exhaust of steam-driven feed pumps, fans, engines, etc. It was generally held that the high water rates for these engines made no difference, so long as there was no excessive exhaust steam to be wasted. The idea was that all the heat exhausted from the engine got into the feed water, so none of it was lost. This sounds fair enough, and is true under certain narrow restrictions. That is, if it is specified that the feed water *must* be heated by auxiliary exhaust, then there is obviously no object in decreasing the water rate below the point where exhaust steam ceases to be wasted. Back of all this reasoning is the old idea that feed heating must come from the steam used to drive the auxiliaries. As soon as this artificial restriction is removed, the true principles involved are seen to be as follows:

Maxims of Good Heat Balance

1. The plant must produce enough power to meet the outside demands.

2. The plant must also produce additional power to meet internal demands (auxiliaries). No pay is received for this portion of the power generated, so it should be kept as low as consistent with good efficiency in other respects.

3. While 1 and 2 have been considered separately and may often for convenience be generated separately, from the point of view of fuel saving they add up to a single total block of power that should be produced with the minimum consumption of coal.

4. The greatest economy will be obtained by heating the feed water with steam from which the maximum amount of power has been obtained whether this power is to be sold outside or used up in the power plant.

The foregoing rules assume that the power generated can be pooled and that the particular steam used for feed heating does not necessarily come from the particular portion generating power for driving the auxiliaries. The relation of auxiliaries to feed heating is more or less accidental. Fundamentally, there is no connection between them.

Economical feed heating is obtained by a wise use of exhaust or bled steam in connection with the generation of a single total block of power. Out of this block the outside power customers are supplied. From the same block must be supplied the inside *customers* namely, the auxiliaries. The less power they take the less waste.

If the auxiliaries are to be steam driven, it saves fuel to make these drives as efficient as possible. If by so doing there is insufficient exhaust steam, a little may be bled from the main turbine around the atmospheric point.

Economy of Electric Drive

The highest plant efficiency can be obtained by driving the auxiliaries electrically from the main unit, and bleeding the turbine for heating the feed water. In this case the main unit, being more efficient, can generate the auxiliary power more economically than can the small auxiliary drives.

The objection to this plan, particularly in the small plant, is that electric drive from the main unit is not sufficiently reliable, at least for feed pumps and circulating pumps. As a result these auxiliaries generally have a steam drive or a combination of steam and electric drive.

Another thing to note is that, for the highest economy, the feed water should be heated by exhaust steam at about its own temperature. It is wasteful of power to heat 90-deg. water with 212-deg. steam, because the steam at 212 might have produced additional power by expanding down to the neighborhood of 90 deg. before being used for heating the feed water. It is generally considered impractical at the present time to carry vacuum on the auxiliaries, but the plan of bleeding the turbine makes it a simple matter to heat feed water by steam that is expanded down to a temperature but little above that of the water it is heating. There is, of course, a practical limit to this, but most of the new large plants find it worth while to bleed the main turbine in from two to four places and heat the feed water by passing it through several successive heaters, the first being heated by the lowest temperature steam, the next by steam of a somewhat higher temperature, and so on. In this way each portion of steam used for heating feed water contributes a maximum amount of power to the total block of power generated. Assuming the power taken by the auxiliaries to be constant, the more total power produced the more will be available for outside distribution per ton of coal burned, and it is this latter quantity that measures the over-all performance of the plant.

Power Generation in Modern Steel Works*

By G. R. McDERMOTT
Assistant Chief Engineer, Illinois Steel Company

THE modern steel plant consists of byproduct coke ovens, blast furnaces, open-hearth furnaces for steel making, rolling mills and power-generating units. The byproduct coke ovens are one of the four important links in the chain of primary units in the steel works. Eighteen to twenty per cent of the calorific value of the coal charged in a coke oven appears as byproducts, consisting of liquid and gaseous products available for steel making in reheating furnaces, ammonium sulphate, the lighter oils, benzol and toluol, etc. Frequently, the surplus coke-oven gas is supplied to municipal gas works. About 70 per cent of the heat in the coal is represented in the coke produced.

This coke is burned in the blast furnaces, which in a steel mill are the greatest consumers of fuel. Also they are the greatest producers of a valuable byproduct, blast-furnace gas, containing about 50 per cent of the calorific value of the coke charged into the furnace. The coke rate of the furnace—that is, pounds of coke per ton of pig iron produced—depends on the efficiency of the furnace; as the coke rate increases, there is an increase in the calorific value of the blast-furnace gas leaving the furnace.

Average Daily Production of Modern Blast Furnace

On an average the modern blast furnace produces 550 tons of pig iron per day, although at the South Chicago plant of the Illinois Steel Co., there are blast furnaces in operation which have averaged 685 tons a day for a month without scrap charge. The quantity of gas produced from a 550-ton furnace at a coke rate of 2,000 lb. will amount to approximately 138,000 cu.ft. per ton of iron, or at the rate of 76,000,000 cu.ft. a day, no allowance being made for a reduction of gas production during the casting period. This gas is distributed approximately as shown in the accompanying table.

DISTRIBUTION OF BLAST-FURNACE GAS

	Million Cu.ft. per Day	Million B.t.u. per Hour	Per centage
Required for blast-furnace stoves	26.6	103	35
Consumed by gas blowing engines	7.6	29	10
Losses	3.04	11.8	4
Surplus available for steam and electric power generation	38.76	150.7	51
Total	76.00	294.5	100

A steel plant with six blast furnaces installed and in operation will therefore produce gas for the generation of power at a rate of 9.66 million cubic feet per hour while all furnaces are active, or at a rate of 7.92 million cubic feet per hour while one of the furnaces is casting.

As it is delivered from the blast furnace, the gas contains dust which should be removed before it is used in the stoves, boilers and gas engines. This is accomplished in a number of plants by washing with water, first by tower washers, known as primary washers, and second by Theisen, or secondary, washers. The primary washed gas is used as fuel for the blast-furnace stoves and steam boilers, while the secondary washed gas is used as fuel for the gas blowing engines supplying the air blast for the furnaces themselves and also for gas engines generating electric power.

Starting with the cleaned gas, the alternatives are the generation of steam for use in engines and turbines or using the gas in internal-combustion engines. The over-all efficiency from fuel to power generated is in favor of the gas engine.

Ten per Cent of Gas Output Used for Blowing

As has been shown in the accompanying table, about 10 per cent of the gas output is used for blowing the furnace, and approximately 51 per cent is available for the production of electric power. The gas engine predominates in the plants of the Illinois Steel Co. for the blowing of blast furnaces and the production of electric power. The engines are of the four-stroke-cycle twin-tandem type and in the case of the electric units are directly connected to three-phase 25-cycle 2,200-volt generators. The thermal efficiency of these units will average 24 per cent for a month at a time for power delivered at the switchboard. The available gas from the hypothetical blast-furnace plant of six furnaces will permit the generation of electric power with internal-combustion engines to the extent of 50,000 to 60,000 kw. per hour, although the steel-mill load for this hypothetical plant will probably average only in the neighborhood of 25,000 kw. per hour.

In the chain of units the open-hearth department is the next link consuming large quantities of fuel. When coke ovens are installed in the steel works, the byproduct gas in combination with the byproduct tar is used as fuel for the open-hearth and reheating furnaces of the rolling mills. In the case of the open-hearth furnaces the thermal efficiency, based on the ratio of net heat used in converting the metal charged in the furnace to steel to the total heat in the fuel supplied, is comparatively low. The efficiency in a well-designed furnace is about 17 per cent. Of the losses 55 per cent is represented in the sensible heat of the waste gases discharged from the furnace stack. By the installation of a waste-heat boiler and economizer about 45 to 50 per cent of the stack losses may be recovered in the form of steam.

From six blast furnaces the pig-iron production will produce 1¾ million tons of steel ingots per annum, assuming that 65 per cent of the material charged into the open-hearth furnaces is hot metal from the blast furnaces. This ingot production would require an installation of twenty-six 100-ton open-hearth furnaces. The temperature of the waste gases at the stack of the furnace varies from 1,100 to 1,300 deg. F. The heat from these gases, when used for the production of steam, is absorbed largely by convection, necessitating the passage of the gases over the heating surface of the boiler and economizer at or near the critical velocity. The rate of heat transfer per square foot of heating surface increases with an increase of the ratio of weight of waste gases per hour to the square foot of gas passage area. It also increases inversely as the diameter of the tube. At the Illinois Steel Co.'s South Chicago plant, fire-tube waste-heat boilers and economizers of home design are installed. Induced-draft fans are necessary to provide for the requirements of the furnace and the draft loss through the waste-heat boiler, which is comparatively high on account of the required high gas velocity through the boiler. These fans may be either motor or steam-turbine driven, depending on the feed-water temperature. The waste-heat steam generated from the 26 furnaces mentioned, would amount to approximately 390,000 lb. per hour from and at 212 deg. F.

Sensible Heat Energy in Exhaust Gases

While on the subject of steam generation from waste gas, it is fitting to call attention to the sensible heat energy contained in the exhaust gases of a modern gas engine. This energy is probably equivalent to between 35 and 40 per cent of that developed by combustion in the cylinder. The temperature of the waste gases near the exhaust valve is about 950 deg. F., and by the installation of a fire-tube type of boiler designed along the lines of a waste-heat boiler for open-hearth furnaces, it is possible to generate 2.25 lb. of steam at 250 lb. pressure per kilowatt generated by the gas engine. The cooling water from the gas engine may be used to heat the feed water going to the boiler. The steam generated in this manner from a large gas-engine installation becomes available for the generation of power in a high-pressure turbo-generator. Based on a 25,000-kw. load, the waste-heat steam from the gas-engine exhaust would generate 3,750 kw. by means of a turbo-generator having a water rate of 15 lb. per kw.-hr. The gross thermal efficiency from fuel to switchboard has thereby been increased from 24 to 27 per cent.

In the rolling mills the main rolls and auxiliary drives of the modern plant are motor driven. The kind of motor installed is determined by the type of mill. The reversing mill requires a direct-current motor, the current for which is supplied through the medium of a motor-generator flywheel set. The continuous mill is driven by either a directly connected low-speed alternating-current motor with flywheel or a high-speed motor with gear reduction

*Paper read before the Chicago section of the American Society of Mechanical Engineers, Jan. 15, 1924.

and a flywheel. These flywheels to a large extent assist in absorbing the local peak loads which otherwise might cause abnormal disturbances at the main generating station. A steel plant having the ingot-producing capacity given, would require on the average 25,000 kw., with momentary peaks up to 35,000.

Summarizing, it is possible in a well-designed steel works to so utilize the waste heat that very little coal will be consumed directly under the boilers for power generation. The bulk of the coal would be consumed in the byproduct coke ovens for the making of coke for the blast furnaces. The steam generated by the utilization of the sensible heat energy in stack gases and gas-engine exhaust would be available for miscellaneous purposes and for electric power generation by turbo-generators installed to assist the gas-driven generators and thus form an elastic combination for absorbing the fluctuating demands from the rolling-mill motors. As has been indicated previously, there will be a surplus of blast-furnace gas over and above that required for electric power generation. Such surplus may be used in combination with producer gas generated from waste coke for heating the coke ovens themselves and thereby increasing the surplus of coke-oven gas for melting in the open-hearth furnaces.

Comparative Tests on Experimental Draft Tubes*

By C. M. Allen† and I. A. Winter‡

When the Alabama Power Co. in 1921 undertook to design and build the new hydro-electric plant known as Mitchell Dam, the matter of proper design of draft tubes for a plant of this type had already received considerable attention from engineers and hydraulic-turbine manufacturers, and there was in evidence a tendency to discard completely the elbow or quarter-turn tube, which for a number of years had been the conventional type of design. Several new and highly efficient tubes designed on basic hydraulic principles had appeared, and the test data and theory on which they were based, together with the actual operating performance at a number of newly completed plants, indicated that the designers had valid claims for efficiencies much higher than could be obtained from tubes of the quarter-turn type. Complete tests of the various types, however, had not not been made under identical conditions, and it was impossible for the prospective user to determine from available published data either the relative merits of the types of tubes offered or the type best suited to his needs. Some of the tests, furthermore, were made with the draft tube acting alone; and, although they were of great value to the draft-tube designer, the performance under this condition obviously did not apply when the tube was operating in connection with a waterwheel. As a result the Alabama Power Co. authorized a series of tests on draft-tube models to be made at the Alden Hydraulic Laboratory of the Worcester (Mass.) Polytechnic Institute, for the purpose of obtaining a direct comparison of the efficiencies of various types of draft tubes and of determining their relative merits under conditions existing at the various power sites in which the company is interested. The tests were made by the writers of the paper under the direction of O. G. Thurlow, chief engineer of the Alabama Power Company.

The model runner used in these tests was a low-head Francis type 10½ in. in diameter, with a specific speed of 66.7, and was homologous with the 130 in. 24,000-hp. runners furnished for the Mitchell Dam development. Of the twelve experimental tubes investigated in this series of tests, six were designed by waterwheel manufacturers, three by the Alabama Power Co., and three were designed and built in the laboratory by those making the tests. The model tubes were designed for identical hydraulic condition, and each was homologous with such a tube of its type as would fit the actual conditions at Mitchell Dam.

Seven Tubes Were Tested

Two series of tests were made. In the first series five tubes were tested, and seven in the second series. As many as twenty-one tests were made on one draft tube. From six to nine gate openings, depending on the shape of the performance curve, were used in each test. Five runs were made for each gate opening, to get the necessary range of speeds, so that from 30 to 45 runs were necessary to complete one test.

Check runs of each test were made. In some cases the tubes were set up a second time and check runs made to see if the manner of setting affected the results. In every case of this nature the check results varied less than 0.2 per cent. In a number of instances check runs showed a variation of less than three-tenths of 1 r.p.m., although several changes in speed had been made in the meantime. On the whole the entire equipment was very sensitive, and any trouble could easily be observed and remedied before the work went forward.

Test data, in the form of efficiency curves showing the best performance of each tube, are included as a part of the paper. There are also included curve sheets showing comparisons of tubes of different types, tubes of the same type and different arrangements of the same tube. A curve sheet showing the best results of each of the twelve tubes under test, may be considered as a summary of the results of this investigation.

In discussing the results of these tests the authors say in part:

An examination of the curves will show that the subject of draft-tube design is well worth serious study and investigation by engineers engaged in all branches of the water-power industry. The relative merits of the modern tubes are not easily determined from these tests. Changes in certain features of design were made in some of the tubes, and tests were made to determine their effect on performance. As these changes were not made throughout the entire set of tubes, a flat comparison of all tubes under identical conditions is not possible, although the effect of the changes on the tube itself may be noted.

An important feature of this investigation is the evidence obtained to the effect that fluctuations in draft-tube pressures vary in degree with the different designs, the fluctuations being least with the most efficient tubes. When the fluctuations were greatest, it was difficult to hold a steady load on the wheel.

Draft-Tube Vacuum

The great difference in vacuum between the outer edge of the tube and the center shows that a piezometer in the customary place—that is, just below the runner on the outer wall—gives no reliable information as to the mean vacuum condition within the tube. In one case a piezometer on the outer edge recorded a positive pressure of about 6 in. of water, due to the centrifugal force of the whirling water, while the center piezometer showed a vacuum of 7½ in. of mercury, or about 15 ft. of water. This high center vacuum just below the runner is no doubt the reason for the better results obtained with the high cones in some of the draft tubes.

The so-called "concentric" tubes were designed with the idea of providing the freest possible flow of water concentric with the vertical axis of the runner. In the "eccentric" tubes the design was modified, with the idea of better meeting structural conditions without unduly sacrificing the hydraulic advantages of the "concentric" tube. The comparative performance of these tubes gives a basis for determining to what extent the designing engineer may be justified in using the more complex designs, which are expensive and introduce serious structural problems, as compared with the simple tubes, which are more readily adapted to design and construction. In any case, the selection of the draft-tube best suited for the type of runner adopted must still be considered as a specific problem in itself.

Although the tests discussed in this paper accomplished the particular purpose for which they were authorized, they are by no means comprehensive or final; and they are submitted with the hope that they will be supplemented by other tests made under different assumptions, from which may be deduced empirical rules that will be of value to the hydraulic engineer.

*Abstract of a paper presented at the power session of the 77th annual meeting of the American Society of Civil Engineers, New York, Jan. 16-18.

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Maps Prepared by Federal Power Commission Will Show Power Interconnection Possibilities

Formula to Show Approximate Cost of Steam Power at Varying Price for Coal

ONE development of the renewed interest in interconnection, which has grown out of the conferences called by Commerce Secretary Hoover, is the fact that the states have very little information as to their own power resources or little precise data as to the domain of each central station. In the area extending from the Richmond, Va., region up the Atlantic coast to the Canadian line, New York, New Hampshire and Maine are the only states that have anything approaching comprehensive information as to the power situation. Pennsylvania is engaged in an intensive power survey at this time.

A series of maps is now being prepared in the offices of the Federal Power Commission with the idea of enabling all concerned to visualize the existing power situation and to gain an idea of the probable trends during the next fifteen years. It is believed that these maps will emphasize the necessity for the movement of power irrespective of state boundaries.

Visualize Existing Power

The basic data being used in the making of these maps is drawn from the files of the Corps of Engineers, of the United States Geological Survey, of the Bureau of the Census, and from the Murray superpower report. In addition, such limited data as can be secured from the states are being used. The maps cover the entire area of the New England and Middle Atlantic States, and of Virginia and West Virginia. One of them shows graphically the total annual kilowatt-hour consumption of electrified and non-electrified power. Another map shows the installed generating capacity and the water power that reasonably may be developed during the next fifteen years.

A third map shows the location of the generating stations, transmission lines and substations of all the utility companies. The operating voltage of the transmission line as shown and the existing points of interconnection are emphasized. A fourth map shows the coal areas in the region with the minimum discharge of the streams large enough to furnish condenser water for large power plants in the coal regions.

Studies are being made of the records of the Bureau of the Census so that the growth of electrified and non-electrified power production in the principal regions may be charted. The curve will be extended so as to show probable power growth during the next fifteen years in Boston, New York, Pittsburgh, Philadelphia, Baltimore, Washington and Richmond. There probably will be a separate curve for the region between Buffalo and Albany.

A formula has been prepared to show the approximate cost of steam power at varying prices for coal. Costs also are being estimated for the transmission of certain blocks of power at high-tension voltage. The idea is to arrive at a computation of the power produced in local steam plants as compared with that brought in as electricity. Diagrams will be prepared also to indicate the probable trends of interconnection.

Interconnect St. Lawrence Power

The study has gone far enough to indicate that existing interconnections are not such as to permit the transfer of any large quantities of power. It also seems apparent that the real stimulus to interconnect will come with the development of large blocks of power on the St. Lawrence, on the Delaware and on the Susquehanna. The development of these streams necessarily will be on a large scale. It will mean that much of the power will have to be transmitted a considerable distance in order to provide the market necessary to absorb it. It also seems probable that this transmission will not follow straight lines. The line will zigzag from market to market and will follow the route of largest local consumption. For instance, when new power is available at Niagara Falls and from the St. Lawrence, it will not move in a straight line to New York City, but probably will go by way of Albany.

While all figures are not in hand as yet, it seems probable that the cost of power at steam plants in the principal Eastern cities varies from ten to twelve mills. If estimates are correct that power can be generated on the St. Lawrence for two mills, the prospects would be that it can be delivered in these cities at a considerably less cost.

Hull, Quebec—The Gatineau Co., Ltd., Montreal, is seeking authorization to develop 100,000 hp. at Chelsea Falls by constructing a dam eight miles northwest of Hull, to cost between $3,000,000 and $4,000,000. At first only half of the total horsepower will be harnessed.

United Engineering Society Elects Officers

William L. Saunders, chairman of the board of directors of the Ingersoll-Rand Co., has recently been elected president of the United Engineering Society, 29 West 39th St., New York City. George H. Pegram, chief engineer of the Interborough lines, was elected first vice-president of the society and J. H. Renders, vice-president of the American Institute of Mining and Metallurgical Engineers, second vice-president. Alfred D. Flinn was chosen secretary, Joseph Struthers, treasurer, and Henry A. Lardner, assistant treasurer.

France Plans Tidewater Power Plant

The French Parliament has passed a law approving a project that will call for the erection of a power plant utilizing tidal energy. The construction will involve a dam of 150 meters and four groups of turbines operating on both the inflow and the outflow of the tide, their power ranging from 75 to 1,200 hp. when running at various speeds. The use of the tides will be carried on with that of the water power drawn from a fresh-water stream in the neighborhood, thus making it possible to regularize the total power produced. Fresh water and tide plants combined will furnish a minimum of 1,600 hp. and a maximum of 3,200 hp. The equipment will furnish power equal to that produced by 16,500 tons of coal per year, according to *Commerce Reports.*

Government To Study Control of Colorado River

A committee composed of five engineers, four of whom are in the service of the government and the fifth an outside engineer, is being organized by Secretary of the Interior Work for the purpose of advising on a definite plan for the control of floods on the Colorado River, the development of its water power and the storage of water for irrigation of arid lands in the lower Colorado River basin.

Secretary Work has appointed F. E. Weymouth, chief engineer of the Reclamation Bureau, to serve on the committee as a representative of the Reclamation Bureau. Herman Stabler was named to represent the Geological Survey, and Col. William Kelly to represent the Federal Power Commission. One representative from the War Department and one engineer not in the employ of the government are yet to be appointed.

St. Lawrence River Project Interests Canada

The Department of State received, on Feb. 5, a reply to a note sent by them to the British Embassy on Nov. 17, 1923, in regard to recommendations made by the International Joint Committee concerning the improvement of the St. Lawrence River between Montreal and Lake Ontario, for navigation and water power.

The British reply recommended that before any work should be carried out, the joint commission should be enlarged and further consider the technical aspects of the problem and decide on the plan that should be adopted; that the government of Canada should form a committee to inquire fully from a national standpoint into the questions involved; that the Dominion government should appoint additional engineers to the joint engineering board.

It is said in official circles, that the United States government is anxious to have the St. Lawrence deep waterway question settled as soon as possible. More than fifteen states will be affected by the improvement as proposed. According to Secretary Hoover New York is coming to see that the benefits obtained from the project would more than offset the temporary disadvantages from which the port might suffer. Secretary Hoover bases his conclusions that New York would benefit from the waterway on the grounds that the 1,250,000 to 1,600,000 hp. developed would be available for use in New York State, especially in the vicinity of the Erie Canal, and that New York would benefit exclusively from this.

It is understood that Prime Minister Mackenzie King of Canada has favored the project, but has been deterred in promoting it actively not only because of the expense involved, but because of opposition from sections of Canada.

Henry Ford's Offer for Muscle Shoals Recommended by Committee

Steam Plant at Lock 17 on Black Warrior River Substituted for Gorgas

A MAJORITY of the members of the Military Affairs Committee of the House of Representatives have joined in recommending the passage of the McKenzie bill, which provides for the acceptance of the offer of Henry Ford for the Muscle Shoals properties of the federal government. No statement was forthcoming at the committee as to the division among its membership, but it is understood that six members will sign a minority report which will be filed during the week beginning Feb. 11.

The committee amended the McKenzie bill so as to substitute for the Gorgas steam plant and transmission line, a steam plant at lock 17 on the Black Warrior River together with a transformer substation, a transmission line and the necessary right-of-way between dam 17 and nitrate plant No. 2 and the Waco quarry. The expenditures in that connection, however, are not to exceed $3,472,487.25, the amount received by the government from the Alabama Power Co. for its interest in the Gorgas plant. The bill also provides that the stock of the company to be formed by Mr. Ford is to be controlled after his death by American citizens only, and that no stock or bonds issued by any company or subsidiary company in connection with the lease of the dams or with nitrate plant No. 2 are to be owned or controlled by any foreign corporation, citizen or subject.

The majority report which has been submitted to the House states that these members are opposed to the government operation of the project and have concluded that the proposal submitted by Mr. Ford approaches more nearly the fulfillment of the intent of Congress as expressed in the National Defense Act. The majority lists its conclusions and justifies them under six heads: First, as to responsibility; second, as to satisfactory fertilizer production and maintenance of nitrate plant No. 2; third, as to the assurance that the benefits of economical production of fertilizers will be passed on to the consumer; fourth, as to a reasonable financial return to the government; fifth, as to the length of the lease period; sixth, as to the conditions during and at the end of the lease period.

Steam Power from Center of Earth Not Practical Yet

The idea of obtaining steam power from the heated center of the earth is not practicable at the present time, according to Dr. Thomas T. Read, of the Department of the Interior, who, with F. C. Houghten, of the research laboratory of the American Society of Heating and Ventilating Engineers, has prepared for the Bureau of Mines a report (service 2554) on the cooling of mine air. In descending beneath the surface of the earth, the temperature increases continuously with depth at a rate varying from one degree Fahrenheit for 70 ft. in depth to one degree in 250 ft., according to the region where it has been measured. Men have ascended over five miles above the surface of the earth; if they could go five miles below the surface in a shaft that deep, a region of high temperature would be reached, and it would seem as though it ought to be possible to utilize that heat as a source of power, free and perpetual. Sir Charles Parsons, the inventor of the steam turbine, has suggested that it is possible, but Dr. Read considers that the difficulties involved would make the power thus obtained too expensive to compete with coal.

The principal difficulty is not the cost of penetrating to so great a depth (though a shaft five miles deep would cost $5,000,000 or more), but the fact that the amount of heat that can be derived from hot rock is not proportional to its temperature, but is limited by the conductivity of the rock. Comparing the heat with water filtering through porous rock, it is evident that the amount of water that can get through in a given time is not dependent upon the amount of water available, or even on its pressure, but depends chiefly on the porosity of the rock. The heat conductivity of rock is low, and in order to get any considerable quantity of heat through in a unit of time the area of surface exposed must be large.

The second important difficulty depends on space; the heat is available five miles below the surface, but it can be usefully employed only on the surface, and how to get it there without losing most of it on the way is the problem. One suggestion is to pass water down and circulate it through large galleries at the bottom, thus giving it time to take up the heat, even at the slow rate of transfer that exists. This would give us water at a high temperature and pressure, but at the bottom of the shaft, where it is no more useful than ice is in the polar regions. In rising to the top of the shaft, the hot water would cool down at about the same rate as it heated up in descending. Even with extremely efficient (and expensive) heat insulation on the upgoing pipe, so much of the heat would be lost that what remained would not pay for the cost of getting it, at least until coal and other sources of power are much more expensive than they are now.

Smoke Damage in Indianapolis $5,000,000 During 1923

In connection with his annual report to the city building commissioner, H. F. Templeton, city smoke inspector, Indianapolis, sets forth that the estimated damage to property in the municipality through excess smoke during the last year stands at $5,000,000, divided as follows: Destruction to merchandise, $2,000,000; destruction of sheet and structural metal work, $1,000,000; defacement of buildings, $500,000; destruction of curtains, draperies and furnishings, $500,000; and fuel loss from imperfect combustion, $1,000,000. It is pointed out that during the year 89 furnaces were rebuilt on orders from the department, and 25 high-pressure boilers and 38 low-pressure boilers were placed in buildings. There were 23 court actions growing out of violations of the city smoke ordinance, and of these, 21 were settled satisfactorily to the city.

A study is now being made by a special committee of the Special Libraries Association of the United States pertaining to trade catalogs, and information is desired as to what firms in this country keep a historical collection of trade catalogs. Information regarding this subject would be gratefully received by L. A. Armistead, librarian, Boston Elevated Railway, 31 St. James Avenue, Room 711, Boston 17, Mass.

Scandinavian Foundation Offers Fellowships

The American-Scandinavian Foundation, 25 West 45th St., New York City, will award not more than twenty fellowships of at least $1,000 each for graduate study and research in the Scandinavian countries. Out of ten subjects for which these fellowships are given two, electrical engineering and hydro-electricity, will interest readers of *Power*. Candidates must have been born in the United States and should be familiar with at least one language beside English, preferably Swedish, Danish or Norwegian. Application papers including letters of recommendation should be filed at the office of the Foundation before March 15.

Public Works Division May Have a Chance

Hearings in the matter of reorganizing the executive departments of the Federal Government were concluded Jan. 31. The feature of the hearing was the objections raised by Cabinet members to the Brown plan.

The widely divergent views of the principal officials of the Administration, as revealed by the hearings, are thought to sound the death knell of any general plan of reorganization. In certain instances the proposed changes possess such evident merit that it seems probable that the committee will advise their proponents to undertake the securing of that particular change by means of separate bills. The record built up during the hearings is admitted to contain further proof of the soundness of the establishment of a division of public works in the Interior Department. There is reason to believe that the report of the committee will give great impetus to the movement looking to such grouping of related activities.

School of Combustion Adds New Course

In view of the fact that during the last few years considerable changes have been made in the production of power by the use of fuels, Mr. Hays and the officers of the Hays School of Combustion, a correspondence school, have decided that the field of combustion is too varied to be served properly by one course. Some men who need training in combustion and the proper handling of fuels are afraid to start in studying the extensive combustion engineer course, but they feel that they do need a course that will teach them practical points in connection with their present jobs, and that will make them more efficient and bring increased pay and promotion. Such a course, practical and not containing mathematical, scientifical or technical discussions, Mr. Hays has started writing. It is designed primarily for firemen and will be of a purely practical nature. When this course is finished, it is intended to add features to the engineering course which will increase its effectiveness in training experts in the theory and practice of combustion engineering.

Thomson To Receive Kelvin Medal at Power Conference

Professor Elihu Thomson, one of the world's most eminent electrical engineers has been awarded the Lord Kelvin gold medal which will be presented at the Kelvin Centenary Celebration to be held in connection with the World Power Conference at Wembley, London, on July 11.

The award was made, by British and American Engineering societies acting jointly, for excellence in original research work in engineering. This medal is awarded every three years. Professor Thomson is the first American to receive this honor.

Professor Thomson became professor of chemistry and physics in the Central High School in Philadelphia during the centennial year, 1876. Becoming interested in electricity he began work on dynamo and electric lighting development while teaching, the result of which was the establishment of the American Electric Co. in New Britain, Conn., which was devoted to the construction of the well known Thomson-Houston electric arc lighting system. This firm was later merged with the General Electric Co.

Elihu Thomson

Professor Thomson has been granted about seven hundred patents in the United States, covering dynamo-electric machinery, electric welding, watt-hour meters, lightning arresters, magnetic-arc extinguishers, etc., beside improving innumerable electrical devices. He has received honorary degrees from many of the important educational institutions in the United States, has been decorated by the French government and has received most of the medals honoring engineers both in the United States and abroad. He is now and has been for many years connected with the managing corporation of the Massachusetts Institute of Technology and was acting president of the Institute from 1920 to 1922. He is a member of most of the various American and British scientific and professional societies.

To Investigate Pittsburgh Power Requirements

The Carnegie Institute of Technology, through its Commercial Engineering Department, is conducting a major investigation of present power requirements and potential future power possibilities in the Pittsburgh District. The investigation is being conducted first, in relation to the community and its development as a whole and, second, with relation to the various specific industries of the community.

Because the largest and most important industrial activity in the district is the production of iron and steel, the first step in the inventory has been to make a detailed study of that industry with relation to its requirements. The first section of this work has recently been completed, according to an article by Lewis Bernstein in Public Service.

Deadlock on New York Water Power Broken

Under the terms of an agreement reached at the executive mansion in Albany recently the political deadlock which has for over twenty years prevented any definite start at power development in New York State was broken and a tentative agreement reached for joint legislative action as a non-partisan measure.

Legislation is to be presented at an early date providing for the creation of a new commission, to be appointed by the Governor, as a State Power Authority, to be organized along the lines suggested in his annual message to the legislature, as outlined in *Power* in the Jan. 8 issue.

An appropriation is to be made and the commission will make another survey of the power situation in New York State and report to the Legislature of 1925 such additional legislation as may be required. Since 1900 there have been something like six surveys made of the power possibilities of the state, so that the new commission to be created will have for its guidance hundreds of printed pages of data and statistics.

Under the terms of the proposed measure the Power Authority will be given the right to issue bonds to raise money for the cost of the development planned, but the year 1924 will be devoted to mapping out an ultimate plan for such development.

According to the reported compromise agreement reached, no individual legislator is to have credit for the bills creating the Power Authority commission but such measures are to be introduced in the Senate by the Finance and in the assembly by the Ways and Means Committee, appropriate committees as they involve the expenditure of money, and given speedy legislative approval.

This action on the part of legislative leaders takes the power development problem out of politics until such a time as the State may show what it can itself accomplish.

It is not regarded as likely that any power development permits will be granted by the Water-Power Commis-

sion the coming year. Since a majority of the present commission took office a year ago, it has been its policy to hold all applications pending action that would fix the state's policy.

Society Affairs

The Pittsburgh Section of the A.I.E.E. will hear C. W. Falls on "Motor Ratings and Application," at its Feb. 19 meeting.

The Detroit Engineering Society will hear Frederick A. Scheffler on "Pulverized Fuel," at its regular meeting at the clubhouse on Feb. 15.

The New York Sections of the A.I.E.E., and the **A.S.M.E.** will hold a joint session on Feb. 27 at which a power subject will be discussed.

The Vancouver, B. C., Section of the A. I. E. E. will have as the subject for its Mar. 7 meeting "Automatic Substation Operating and Some Features of Power Factor Correction." The speaker will be R. L. Hall.

The American Institute of Mining and Metallurgical Engineers will hold a symposium on petroleum and gas at its annual meeting in New York City on Feb. 18, at which E. DeGolyer, of New York, will deliver a paper on "Production of Petroleum in 1923." A session on coal and coke is also on the program.

The Illinois Society of Engineers has recently decided to extend its field by the organization of a new section to include mechanical, electrical and mining engineers. Formerly, the society was chiefly concerned with matters relating to civil engineering. H. E. Babbitt, Urbana, Ill., is the secretary for 1924.

The Baltimore Section of A.S.M.E. will hold a joint meeting on Mar. 1 with the A.I.E.E. at Holtwood to inspect the new hydraulic installation. A paper "The Pennsylvania Water Power Co.," will be delivered by Messrs. Higgans and Thomas. F. H. Rogers will speak on "Waterwheel Installations," and J. Walter May on "Construction Phases."

The New England Coal Wholesalers are planning a conference at the Boston City Club on Feb. 13 to make plans for a "burn coal" campaign. Perry Barker, Boston fuel engineer, will speak on "The Relative Value of Coal and Oil in Stationary Boilers"; F. H. Daniels, of Worcester, will talk on "Modern Stokers for Burning Coal"; Henry Kreisinger, formerly of the Bureau of Mines, will discuss, "The Use of Pulverized Coal in Power Plants"; Prof. Edward F. Miller, mechanical engineer, Massachusetts Institute of Technology, will have as his subject, "Fuels in General."

Personal Mention

S. S. Howell announces his return to advisory engineering practice in matters of power, mechanical and electrical with offices at 608 S. Dearborn St., Chicago, Ill.

Boyd H. Remaly, formerly connected with The Indemnity Insurance Co. of North America, has recently been appointed chief engineer in charge of the engineering and inspection department of the Independence Indemnity Co., Philadelphia, Pa.

Coming Conventions

American Electrochemical Society. C. G. Fink, Columbia University, New York City. Meeting at Hotel-Bellevue-Stratford, Philadelphia, Pa., April 24-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Spring convention at Birmingham, Ala., April 7-10.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 18-21.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29, formerly announced, May 19-22.

American Water Works Association. J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

Association of Iron and Steel Electrical Engineers. W. M. Chandler, 708 Empire Building, Pittsburgh, Pa. Fuel Saving Conference—Combustion Engineers. April 2-3.

Indiana Engineering Society. Charles Brossman, 1503 Merchants Bank Bldg., Indianapolis, Ind. Annual meeting at Lincoln Hotel, Indianapolis, Ind. Feb. 14-15.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Kansas Association** at Parsons, Kans., April 16-18. J. M. VanSant, 739 Horne St., Topeka, Kans. **Indiana Association** at La Fayette, Ind., May 5-6. Prof. A. W. Cole, Purdue University, Lafayette, Ind. **New Jersey Association** at Newark, June 6-8. Joseph P. Flynn, 16 Palmer St., Elizabeth, N. J. **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Waterhouse Block, Cedar Rapids, Iowa. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at Bridgeport, Conn., June 27-28. George F. Klopfer, 30 East Pearl St., New Haven, Conn. **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass.

National District Heating Association, D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 11-14, 1924.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Buffalo, N. Y., April 30 to May 2, 1924.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

Louis T. Klauder, consulting engineer, announces the removal of his offices to the Bankers Trust Bldg., Philadelphia, Pa.

John J. Noell, formerly with the Electrical Company of Wilmington, Del., has recently been appointed engineer in the electrical division of Stone & Webster, Inc., Boston, Mass.

Roy R. Burnham, who has been engaged in practice for the past four years as a consulting engineer, with offices at 119 Water St., Boston, Mass., has been elected treasurer of the Walworth-English-Flett Co., 100 Pearl St., Boston, Mass., engineers and contractors specializing in high- and low-pressure steam piping, heating, ventilating, sprinkler and refrigerating installations.

Business Notes

The Permutit Company, 440 Fourth Ave., New York City, has opened a new branch office at 250 West Lafayette Blvd., Detroit, Mich., under the management of Benjamin Soffe.

The Graver Corporation, East Chicago, Ind., manufacturers of tanks, water softeners, etc. has appointed L. H. Welling, manager of its Eastern office, 5045 Grand Terminal Bldg., New York City.

The Westinghouse Electric & Manufacturing Co. has announced the appointment of the Mann Electric Supply Co., of Columbia, S. C., as its representative in distributing electrical apparatus.

Day & Zimmermann, Inc., Engineers, 2 Wall St., New York City, announce that George W. Mixter has become associated with their organization and will give special attention to industrial work.

The Girtanner Engineering Corp., of 1400 Broadway, New York City, manufacturer of conveyors, announces that the Lew Sales Co., Central Bldg., Rochester, N. Y., has been appointed district representative for northern New York and that the Horace Mann Manufacturing Co., 122 Third St., Muskegon, Mich., district representative for Michigan.

The McClave-Brooks Co., Scranton, Pa., maker of stokers, grates, etc., announces changes in its sales organization: The St. Paul office, formerly a branch of the Chicago office, becomes the Northwestern district office, with L. A. Picha as manager; J. C. Saunders, becomes manager of the Western district office at Chicago; B. L. Sanders will assume the managership of the Southern district office at Greenville, S. C.; sales in the State of Kentucky are to come under the jurisdiction of the Southwestern district office at Memphis, D. G. Counts, manager; E. G. Whittemore becomes district sales manager of the Scranton territory; C. A. Warg succeeds Mr. Whittemore as manager of the engineering and designing departments.

Trade Catalogs

Buckets, Clamshell—Blaw-Knox Co., Pittsburgh, Pa. Catalog No. 24 describes clamshell buckets, cableways and other rehandling devices. Useful tables, diagrams and illustrations add to the interest of this 51-page catalog.

Blower, Turbine—L. J. Wing Manufacturing Co., 352-362 West 13th St., New York City. Bulletin 67 describes with illustrations, tables of dimensions and graphs, the installation and operation of these blowers for every boiler stokered or hand fired.

Instruments, Recording—C. J. Tagliabue Manufacturing Co., 18-88 Thirty-third St., Brooklyn, N. Y. Catalog 904 gives descriptions and pictures of thermometers, controllers, gages, records, testing instruments, hydrometers and other products manufactured by this company.

Meters, Watthour—Sangamo Electric Co., Springfield, Ill. Bulletin No. 64 describes the design, principles and construction of these mercury-type direct-current watthour meters. Tables of dimensions, internal circuits and train rations and disk constants as well as a price list add to the usefulness of the catalog.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Jan. 28, 1924	Feb. 4, 1924
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.25	2.25
Clearfield	Boston	2.25	2.50
Somerset	Boston	2.50	2.50
Kanawha	Columbus	1.75	1.75
Hocking	Columbus	2.00	2.00
Pittsburgh No. 8	Cleveland	2.00	2.10
Franklin, Ill	Chicago	2.50	2.50
Central, Ill	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.75	2.75
West Ky	Louisville	1.75	1.90
S. E. Ky	Louisville	2.00	2.00
Big Seam	Birmingham	1.85	1.85

FUEL OIL

New York—Jan. 31, light oil, tank-car lots, 28@34 deg. Baumé, 5c. per gal., 36@40 deg. 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Jan. 28, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95@$2 per bbl.; 26@28 deg., $2@$2.05; 28@30 deg., $2.05@$2.10; 32@36 deg., gas oil, 5½c. per gal.; 36@40 deg., distillate, 6c. per gal.

Pittsburgh—Jan. 31, f.o.b. local refinery, 30@34 deg., fuel oil, 5½c. per gal.; 36@40 deg., fuel oil, 5½c.; 34 deg., neutral 8½c. per gal.

Dallas—Feb. 1, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Cincinnati—Feb. 7, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 6c. per gal.; 30@32 deg., 6½c.; 38@42 deg., distillate, 7½c. per gal.

Philadelphia—Feb. 2, 28@30 deg., $2.31@$2.36 per bbl.; 18@22 deg., $2.10@$2.16½; 13@16 deg., $1.45@$1.51½ per bbl.

Boston—Jan. 28, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4⅝c. per gal., light oil, 28@32 deg. Baumé, 6⅝c. per gal.

Chicago—Jan. 19, 24@26 deg., $2.12 per bbl.; gas oil, 32@36 deg., 4.93c. per gal.

New Plant Construction

Ala., Albany — The Decatur Cornice & Roofing Co., Inc., is planning for the early purchase of an air compressor, capacity about 400 cu.ft. per min.

Ala., Camp Hill—The Trout Lumber Co., recently organized, plans for the construction of a steam power plant at its proposed local mill, with return tubular boiler, engine and auxiliary equipment. H. W. Trout is secretary and treasurer.

B. C., Vancouver—The British Columbia Electric Railway Co. has plans for the construction of a hydro-electric power plant at Stave Falls, estimated to cost close to $1,000,000.

Calif., Exeter—The San Joaquin Valley Portland Cement Co. is planning to commence erection at an early date of its proposed cement plant and power house in the Three Rivers district, estimated to cost $1,000,000, with equipment. The company was organized a few months ago and is affiliated with the Old Mission Portland Cement Co., Crocker Building, San Francisco. S. A. Parker and G. F. Hamburg, are heads.

Calif., Lankershim—The Lankershim Ice Co. is planning for the construction of an addition to its ice-manufacturing plant, to provide for an increase of about 30 tons per day. W. F. Brown is president.

Calif., Los Angeles—The Board of Public Service Commissioners has made application to the State Water Department for a permit to install and operate hydro-electric power plants on Rock Creek and the East Fork of Rock Creek, Mono County, to develop a total of 12,300 hp., estimated to cost $1,705,000.

Calif., North Sacramento — William J. Kerth, 1401 Forty-third Street, Sacramento, has acquired a site on the Del Paso Boulevard, for the erection of a one-story ice-manufacturing plant, for which plans will soon be prepared.

Calif., Palo Alto—The medical officer in charge, United States Veterans' Hospital, will take bids at once for the installation of a raw-water ice-manufacturing plant, and complete refrigerating plant. The closing date for bids has not been announced.

Calif., Santa Barbara—The City Council is said to be planning for the installation of an electric-operated pumping plant in connection with proposed extensions in the sewerage system, estimated to cost $150,000. George D. Morrison is city manager.

Calif., Tracy — The Board of City Trustees has authorized the purchase of additional electric-operated pumping machinery for installation at the waterworks station. W. D. Harrington is city engineer.

Del., Wilmington—The Modern Bond Co., West Fifth Street, is considering the construction of a power house at its proposed plant on site recently acquired on the Lincoln Highway, Elsmere, for the manufacture of metal collapsible tubing, estimated to cost $210,000.

Del., Wilmington — The Wilmington & Philadelphia Traction Co. has filed plans for the immediate erection of an addition to its steam power plant at the foot of Buena Vista Street, to cost about $50,000.

Fla., Cocoanut Grove — The Common Council plans for the installation of an electric-operataed pumping plant at its proposed municipal water plant, for which a bond issue of $200,000, is being arranged.

Fla., Fellsmere—The Standard Agricultural & Chemical Co., will construct a steam-operated electric power plant at its proposed local mill for the manufacture of fertilizer products, estimated to cost $350,000. E. P. Decker is engineer in charge of construction.

Fla., Jacksonville—The Imperial Oil Co., Tampa, Fla., will install a pumping plant at its proposed local storage and distributing works, estimated to cost about $200,000.

Fla., Miami—The Department of Public Utilities, Ernest Cotton, director, plans for the installation of additional pumping machinery at the Hialeah water plant.

Fla., Miami — The Royal Palm Sugar Cane & Planting Co., recently organized, has tentative plans under consideration for the construction of a power plant at its proposed sugar cane development and grinding mill in the Lower Everglades, on 30,000-acre site, lately acquired. Paul C. Taylor, Miami, attorney, is an official of the company.

Ga., Macon—The C. W. Barber Co. is planning for the purchase of an engine, boiler, and auxiliary equipment for a power house, to be used in connection with a saw mill.

Idaho, St. Anthony—The Common Council plans for the installation of electric-operated pumping machinery in connection with proposed extensions and improvements in the municipal waterworks, to cost $75,000.

Ind., Bloomington—The Showers Brothers Furniture Co. has plans nearing completion for the construction of a steam-operated electric power plant for service at its mills, estimated to cost $400,000.

Ind., Hobart—The National Fireproofing Co., Fulton Building, Pittsburgh, Pa., plans for the rebuilding of the portion of its local plant and power house, recently destroyed by fire with loss of about $400,000, including equipment.

Iowa, Fort Dodge—The Lutheran Community of Fort Dodge, T. K. Peterson, Badger, Iowa, president, in charge, is considering the construction of a power house at its proposed local hospital, estimated to cost $210,000.

Iowa, Wyoming — The Village Council has tentative plans under consideration for the construction of a municipal electric power plant, to cost approximately $35,000. It is proposed to select an engineer at an early date. E. M. Babcock is mayor.

Kan., Fredonia—The City Council has plans in preparation for the construction of a municipal electric power plant, and electrification of the existing waterworks pumping station, estimated to cost $150,000. Arthur L. Mullergren, Gates Building, Kansas City, Mo., is engineer.

Ky., Morganfield—The City Council plans for the installation of electric-operated pumping machinery at the proposed municipal waterworks, for which a fund of $120,000, has been arranged.

La., Coushatta — The Common Council plans for the installation of electric-operated pumping machinery in connection with the proposed waterworks and sewerage systems, estimated to cost $70,000.

Md., Baltimore—The Board of Trustees, Johns Hopkins University, will commence the immediate erection of a power plant at the institution, Wolf near Monument Street, for which a building contract has been let to the Consolidated Engineering Co., Calvert Building. It will cost $750,000, with equipment.

Md., Cumberland—The Glendale Co., Inc., has plans for the installation of an electric-operated pumping plant and reservoir, with capacity of 300,000 gals. F. S. Deekens, Jr., is secretary.

Md., Cumberland—W. R. E. King, now organizing a local company to construct and operate a glass manufacturing plant, plans for the erection of a power house at the proposed works, estimated to cost close to $80,000.

Mass., Holyoke — The John P. Squires Co. is reported to be planning for the construction of a new cold storage and refrigerating plant for its meat-packing

business replacing a plant recently sold to Swift & Co.

Mass., Springfield—The United Electric Light Co. is planning for extensions in its generating plant, including the installation of additional equipment. A portion of a stock issue of $800,000, soon to be sold, will be used for the work.

Mich., Detroit—The Michigan Artificial Ice Products Co., 1001 Real Estate Exchange Building, Milton Carmichael, secretary, has tentative plans for the construction of a series of ice-manufacturing plants in a number of cities in the state.

Mich., L'Anse — The Ford Motor Co., Highland Park, Detroit, Mich., has plans for the construction of a local pumping plant, with two electric-operated pumping units, and auxiliary equipment.

Mich., Lansing—The Hugh Lyons Co., operating a local plant for the manufacture of store fixtures, etc., is planning for extensions in its power house, with the installation of additional engines, generators, boilers and auxiliary equipment.

Minn., Brainerd — The Northern Pacific Railroad Co., Fifth and Jackson Streets, St Paul, Minn., has completed plans for a power house at its proposed local repair shops, and is expected to take bids for building and equipment at an early date. The project will involve about $600,000.

Minn., Fergus Falls—C. L. Alexandria, and associates, have plans under consideration for the construction of a central steam power plant for heating service in the city district.

Minn., Minneapolis — The Waterworks Department, J. A. Jensen, supervisor, is having plans completed for an electric-operated pumping station and filtration plant in the Fridley Park section, estimated to cost $3,000,000, with equipment. Fallows & Huey, New York Life Building, are engineers.

Minn., Willmar—The City Council, Hans Gunderson, city clerk, will receive bids until Feb. 18, for equipment for a municipal power plant, including one 750 kw. turbine, or engine-driven generator; three 300 hp. water-tube boilers, with superheaters, etc.; and three underfeed mechanical stokers. Toltz, King & Day, Inc., St. Paul, Minn., is engineer.

Miss., Jackson—The American Box Factory, Inc., Leesburg, Va., plans for the construction of a power house at its proposed local plant, estimated to cost $60,000.

Mo., St. Joseph—The Board of Public Works has tentative plans under consideration for extensions and improvements in the municipal waterworks, with the installation of electric-operated pumping machinery, estimated to cost $600,000. W. K. Seitz is engineer in charge.

Mo., St. Louis—The American Thermometer Co., 3146 Lucas Avenue, plans for the rebuilding of its boiler plant, recently destroyed by fire.

Neb., Neligh—The Common Council is considering the installation of a municipal waterworks, with electric-operated pumping equipment, expecting to commence work in the spring.

Neb., Omaha — The Board of Trustees, Creighton University, Burt and Twenty-fourth Streets, has tentative plans in progress for the erection of a power plant at the institution. John Latenser & Sons, Peters Trust Building, are architects.

N. J., Bayonne—The Baker Castor Oil Co., Avenue A and Second Street, has filed plans for the immediate construction of a one-story boiler house for factory service.

N. J., Burlington—The City Council is having plans drawn for the installation of an electric-operated pumping station in connection with extensions in the sewerage system, to cost about $30,000. Sherman & Sleeper, Fifth and Cooper Streets, Camden, N. J., are engineers.

N. J., Pleasantville—The Peerless Plush Mfg. Co., 71 Franklin Street, Paterson, N. J., plans for the construction of a power house at its proposed local mill, on site recently acquired, estimated to cost $230,000. Russell G. Cory, 30 Church Street, New York, is architect and engineer.

N. M., Silver City—The American Alum Corporation has plans under way for the construction of a hydro-electric power plant on the Gila River, to be used for service at its local properties, with estimated cost reported at $90,000. Headquarters of the company are 55 Liberty Street, New York.

N. Y., Auburn—The Board of Trustees, City Hospital, plans for the construction of a steam-operated power plant at the proposed institutional building to cost $660,000. S. F. Hilger and C. C. Tallman, Seward Building, Auburn, are associated architects; A. R. Acheson, Robbins-Eckel Building, Syracuse, N. Y., is steam engineer.

N. Y., Colonie — The Taylor Electric Truck Co., manufacturer of railway equipment, is reported to be planning for the construction of a power house in connection with the proposed rebuilding of the local plant, partially destroyed by fire, Feb. 2, with loss of about $275,000.

N. Y., New York—The Libby Baths Corporation, care of Gronenberg & Leuchtag, 450 Fourth Avenue, architects, plan for the installation of a steam power plant, with pumping machinery and auxiliary equipment, in its proposed ten-story hotel, to be erected at Delancey and Chrystie Streets, estimated to cost $1,250,000, for which bids will soon be asked.

N. C., Raleigh—The Board of Trustees, Meredith College, plans for the construction of a steam-operated electric power plant at the proposed institutional buildings on tract of 135 acres of land acquired on the Durham Highway, to cost approximately $3,500,000. Wilson, Berryman & Kennedy, Columbia, S. C., are architects. W. N. Jones is president.

N. C., Robersonville—The Common Council is reported to be planning for the installation of electric-operated pumping machinery in connection with water and sewerage systems, estimated to cost $100,000, for which bonds are being sold.

Ohio, Bellaire — The Bellaire Enamel Co. contemplates the construction of a power house in connection with the rebuilding of its plant, recently destroyed by fire with loss of about $400,000, including equipment.

Ohio, Toledo—The Libbey-Owens Sheet Glass Co., Nicholas Building, will build a power house at its proposed glass works on site near the city limits, estimated to cost in excess of $500,000, for which bids will be called on revised plans at once. Lockwood, Greene & Co., 24 Federal Street, Boston, Mass., are architects and engineers.

Okla., Heavener—The City Council has tentative plans for the installation of a new waterworks plant, including an electric-operated pumping station, estimated to cost $150,000, for which bonds will be arranged at an early date. V. V. Long & Co., Colcord Building, Oklahoma City, Okla., are engineers.

Okla., Okema—The Common Council is considering the installation of electric-operated pumping equipment at the proposed municipal waterworks, to cost about $65,000.

Ore., Hood River—The Oregon Power Co. is planning for the installation of a hydro-electric power plant on the East Fork of the Hood River, for service at its mill, estimated to cost $50,000.

Ore., Vernonia—The Common Council plans for extensions in the municipal waterworks, with the installation of additional pumping macinery, estimated to cost $60,000.

Pa., Du Bois—The Buffalo Slag Co., Ellicott Square, Buffalo, N. Y., is considering the construction of a power house at its proposed local plant, to cost in excess of $85,000.

Pa., Philadelphia—Bids are being asked by the Ford Motor Co., Highland Park, Detroit, Mich., for the erection of its proposed local assembling plant and power house on the Schuylkill River, estimated to cost $1,000,000, to be received about Feb. 16. Albert Kahn, Marquette Building, Detroit, is architect.

Pa., Philadelphia—William D. Whitaker, N and Sedgley Streets, will soon commence the construction of a one-story power house for service at a proposed textile mill, adjoining, estimated to cost $105,000.

Pa., Quakertown — The Pennsylvania Power & Light Co., Allentown, Pa., is negotiating for the purchase of the local municipal power plant for a consideration stated in excess of $100,000, and proposes to operate as a private plant in the future.

R. I., Providence — The Narragansett Electric Lighting Co. has completed plans for extensions and improvements in its steam power plant on Eddy Stret, including the installation of additional equipment, estimated to cost $1,000,000. Jenks & Ballou, Grosvenor Building, are engineers.

S. C., Cayce—Corley Brothers, Inc., recently organized by J. R. and E. J. Corley, Lexington, S. C., will construct a power house at its proposed local lumber mill, estimated to cost $85,000. G. A. Cralle will act as superintendent in charge of construction.

S. C., Chester—The Chester Ice & Fuel Co. has tentative plans for the construction of an ice-manufacturing plant on Center Street, with initial capacity of about 30 tons per day.

S. C., Florence — The Common Council plans for the installation of an electric-operated pumping plant at the proposed waterworks, estimated to cost $250,000. Water rights have been secured on Black Creek.

Tenn., Ashwood—The Ridley Phosphate Co. is considering the construction of a power house at its local phosphate works, to include a development of more than 400 acres of land.

Tenn., Friendship—A company is being organized by A. P. Nettles, and associates, to install and operate a local steam-electric power plant for municipal service.

Tenn., Knoxville—The Board of Public Works has tentative plans under advisement for the installation of an electric-operated pumping plant on Williams Creek, in connection with proposed extensions and improvements in the municipal waterworks to cost approximately $2,000,000.

Tex., Corpus Christi — The Gulf Coast Power Co. plans for extensions in its local power plant, including the installation of a 1,500 hp. turbo-generator, and auxiliary equipment.

Tex., Lockhart—The Citizens' Water & Light Co. has preliminary plans for the construction of a cold storage and ice-manufacturing plant. The company has recently increased its capital to $100,000 for expansion.

Tex., Marble Falls — The Marble Falls Textile Mills Co., recently organized with capital of $350,000, plans for the construction of a water power and steam power plant at its proposed mill on site acquired on the Colorado River, estimated to cost $250,000. R. E. Witt heads the company, which is represented by Jack Hyman, attorney, Dallas, Tex.

Tex., San Antonio—The Beacon Hill Ice Co. has plans for the construction of a one-story ice-manufacturing plant on Woodlawn Avenue, 80 x 100 ft., estimated to cost $100,000, with equipment. L. L. Stephenson, 212 Garza Street, is general manager.

Tex., Winters — The Common Council plans for the installation of electric-operated pumping machinery at the proposed municipal sewerage plant, for which plans will be prepared by the Municipal Engineering Co., Dallas, Tex.

Vt., Dorset—The Manchester Marble Co., 117 West Street, P. R. Eaton, head, plans for the construction of a power house at its proposed local mill, for which foundations will be commenced at an early date.

Va., Blackwood—The Blackwood Coal & Coke Co. plans for the construction of a power plant at its proposed new mining town, to be known as Calvin. The station will be used for service at the mines, as well as for the community. The entire project involves in excess of $4,000,000.

Va., Wise City—The Common Council is considering the installation of electric-operated pumping machinery at the proposed municipal waterworks and sewerage system.

Wash., Blaine — The Wyatt & Miller Lumber Co. plan for the construction of a steam-operated power house at its proposed local mill. C. L. Flyn, head of the Bellingham Stevedoring Co., Bellingham, Wash., is interested in the company, which was organized recently.

W. Va., Charleston—The Virginian Rubber Co. is perfecting plans for the construction of a power house at its plant in the Highlawn section, to be rebuilt, following a recent fire loss of about $200,000. It is proposed to call for equipment bids in April. G. C. Hedrick, Beckley, W. Va., is president.

Wis., Lancaster—The Board of Works has plans in progress for the electrification of the present steam-operated pumping station and waterworks. Two pumps of 300 and 500 g.p.m., respectively, will be purchased, motor-driven. W. G. Kirchoffer, Madison, Wis., is engineer.

Wis., Tomah—The Common Council is having plans prepared for an electric-operated pumping station and other improvements in the waterworks. A centrifugal pumping unit, 300 g.p.m. capacity will be installed, with auxiliary equipment. W. G. Kirchoffer, Madison, Wis., is engineer.

Wis., Watertown—The Rock River Paper Co., contemplates the construction of a power house at its proposed local paper mill, on site recently acquired, estimated to cost in excess of $200,000, with equipment. William C. Stone, Bank of Watertown, is interested in the project.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Steam and water hose prices higher; rubber belting also advanced, during month. White and colored cotton waste up in New York and Cleveland warehouses. Higher prices being offered for washed white wiping cloths. Advances in waste and wipers due to cotton textile situation. While linseed oil, the great paint barometer, has remained steady during month, white and red lead rose ½c. per lb., f.o.b. New York. Structural and boiler rivets higher at mill. Chrome cement and crude ore up. Babbitt metal advanced 1½ to 2c. per lb. in Cleveland.

Declines—Slightly higher discounts on high pressure pipe and boiler covering. No other declines reported.

POWER-PLANT SUPPLIES

HOSE—

Fire			50-Ft. Lengths
Underwriters' 2½-in., coupled			56c. per ft.
Common, 2½-in., 3-ply	$1.00 per ft. list less		40–5%
Air—Best grade			
¼-in., per ft.	3-ply $0.33	4 ply	$0.40½
Steam—Discounts from List			
First grade 30–10%	Second grade 40–5%	Third grade	40–10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Second grade	50–10%	Best grade	50–5%

LEATHER BELTING—List price, 2c. per sq. in., per ply.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING { For cut, best grade, 45–5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ¼ in.	$0.90
Asbestos for high-pressure steam, ¼ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.64 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	20.00	14.00
Colored	9@12½	17.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	16.00	16.00
New York	11.00	11.50
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.95	$1.00	$0.94

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	14.50	14.25	16.00	15.75
White	14.50	14.25	14.50	14.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50%	60%	60%
Tinned	50%	60%	4½c. per lb. net

Structural rivets, ½ . ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.
New York $4.40 Chicago $3.75 Pittsburgh $2.90
Boiler rivets, same sizes:
New York $4.50 Chicago $3.85 Pittsburgh $3.10@3.15

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$50@55
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	27@32
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31@36
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	42.00@43.50
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	41@48
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	42@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	36@43
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	18.00@23.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	52.00	61.00	48@52
(35% tin)	25.00	20.50	22@25

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.40	$3.90	$4.30
Flats, square and hexagons, per 100 lb. base	4.90	4.40	4.80

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
4	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
1	.20	.25	.21
1¼	.23	.29	.23
1½	.24	.33	.28
2¼	....	....	....
2	.30	.41	.32
2½	.32	.47	.35
3¼	.34	.51	.37
2	.43	.64	.47

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 43.50 (net)	$ 70.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	45%	25%
1,000 to 5,000 ft.	50%	30%
5,000 ft. and over	55%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
⅜	79.20	84.95	13.00	14.49	8.18	8.78
½	112.06	122.19	19.26	21.46	10.65	11.42
¾	151.62	165.31	25.65	28.33	14.76	15.78
1	181.28	197.67	34.19	37.77	18.23	19.47
1¼	248.90	265.94	62.70	69.24	24.29	25.97
1½	385.50	420.48	102.58	111.33	34.71	37.10
2	504.29	548.81	273.40	302.12	51.66	55.63
2½	633.86	688.65	604.03	667.15	69.41	74.19
3	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.47	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$22.00
No. 16 cotton reinforced heavy	25.50
No. 18 cotton reinforced light	19.00
No. 16 cotton reinforced light	21.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2 70
0-30 ampere, less than standard package	3 00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.30	$0.35	120	50	$0.45	$0.45	60
15	.30	.35	120	75	.50	.55	60
25	.30	.35	120	100	.60	.65	24
40	.30	.35	120	150	.75	.80	24
50	.30	.35	120	200	1.00	1.10	24
60	.35	.40	120	300	1.60	1.70	24
				500	2.35	2.50	12
				750	3.75	3.95	8
				1.000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.1d
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Composition—2 Pc. Plug—Composition	0.8½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York,

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.00	$ 9.51	$12.50	$17.85
12	9.50	12.25	13 90	23.40
10	12.70	15.90	17.90	29.00
8	17.40	20.75	22.25	39.00
6	.....	.....	32.75	.....
4	.....	.....	44.50	.....
2	.....	.....	64.90	.....
1	.....	.....	85.50	.....
0	.....	.....	114.00	.....
00	.....	.....	132 00	.....
000	.....	.....	159 00	.....
0000	.....	.....	189.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61
Less 1-5th standard package				25%	
1-5th to standard package				32%	
Standard package				37%	

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%